Chapter 9

What are the Macroeconomic Impacts of Natural Disasters? - The Impacts of Natural Disasters on the Growth Rate of Gross Prefectural Domestic Product in Japan

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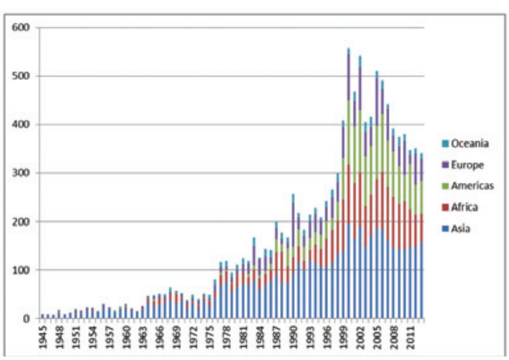
1. Introduction

Typhoon Haiyan, one of the strongest storms ever recorded, swept across the central Philippines with gusts of up to 200mph (320km/h) on November 8, 2013. It has been estimated that the cost of reconstruction will reach almost US$6 billion. Japan also suffered huge earthquake on March 11, 2011, the Great East Japan Earthquake, the fourth largest in recorded history. The earthquake caused a major tsunami on a scale that occurs only once every few hundred years, claiming around 20,000 lives. As the following figure shows, in the last two decades there has been an upward trend in the number of disasters.[1]

Figure 1. Regional Distribution of the Number of Natural Disasters



Source: Author's calculation (2014) based on the data by the EM-DAT/CREDS.

1. The EM-DAT database constructed and maintained by the Centre for Research on the Epidemiology of Disasters (CRED 2010). The EM-DAT database is global, and contains natural disaster data (e.g., geophysical, meteorological and climatological natural disasters) from 1900 to the present.

As the frequency of disasters increases rapidly, the need to build social resilience becomes more and more important.

So far, there has been widespread debate over the long-term economic and macroeconomic impacts of natural disasters (Skidmore and Toya 2002). Economic analysis of natural disasters has only just started. In the past, only a small number of papers attempted empirical analysis, but the number has been growing over the last few years. There is no consensus as to whether natural disasters have positive or negative impacts. There is a strong need for more empirical studies.

As we will see in detail in the next section, previous literature has failed to capture the heterogeneous characteristics of natural disasters. Most studies use the number of disasters occurring across countries as an explanatory variable. Considering the nature of most disasters, their direct impacts are local rather than national. Hence, for empirical study, it seems more appropriate to use disaggregated data to capture the heterogeneous nature of disasters. For example, in the case of Japan, prefectural data on disasters is available. Utilizing these data, we would be able to capture a better picture of the macroeconomic impacts. Furthermore, most studies analyse the correlation between economic growth and the number of natural disasters. Since natural disasters have different effects depending on various conditions (e.g. the impact of earthquakes is different depending on their magnitude), it seems more appropriate to use data such as the total amount of damage expressed in monetary terms and the number of victims (including both dead and injured), rather than the number of disasters, to capture the real impacts.

To tackle these issues, this paper investigates the impacts of natural disasters on the growth rate of gross prefectural domestic product, utilizing the 47 prefectural governments' unbalanced panel data for Japan for twenty years from 1975 to 1995.

2. The macro-economic impacts of natural disasters in previous research

There is an on-going debate, as we will see, on whether disasters have positive or negative macroeconomic impacts. Some analysts have found that natural disasters are detrimental to economic growth, but others have found them to be a form of "Schumpeterian creative destruction."

There is a need for more empirical study, and this paper aims to contribute to this debate.

Disasters can be classified into three categories, according to the Center for Research on Epidemiology of Disasters (CRED, 2010): natural disasters, technological disasters (e.g. industrial accidents), and man-made disasters (e.g. war, financial crises). This paper focuses only on natural disasters. Macroeconomic impacts can be different depending on the time frame (short term or long term). This section reviews existing studies that classify these two frameworks. Many past studies have used cross-country panel data, which is available from EM-DAT. However, there are very few papers that examine the impacts on a specific country (e.g. Noy and Vu 2010, on Vietnam; Rasmussen 2004, on several Caribbean islands). This paper is an attempt to contribute further to the discussion.

2.1 Short-and middle-term impacts of disasters

The analyses of short- and middle-term impacts vary. The field of studies on the economic impacts of disasters started with the short-term effects on the economy. The growth model approach to natural disasters was first introduced by Dacy and Kunreuther (1969). They found that Gross Domestic Product (GDP) tends to increase immediately after a natural disaster. This analysis was supported by empirical studies by Albala-Bertrand (1993a; 1993b). They developed an analytical model of disasters and response and collected data on disasters (28 disasters in 26 countries during 1969–79). Using before–after statistical analysis, Albala-Bertrand found that the following variables increase: GDP, capital formation, twin deficits, and agricultural and construction output. He concluded that capital loss is unlikely to have a profound effect on growth and that a very moderate response expenditure may be sufficient to prevent the growth rate of output from falling.[2]

Chaveriat (2000) and Hochrainer (2009), however, found a mixed picture. Chaveriat found a pattern of GDP decreasing in the year of the disaster, followed by growth over the subsequent two years. The growth

2. He found no long-run effects in developing countries. His finding was that in developing countries aggregate negative effects lasted only two years. Hence, he concluded that natural disaster effects are primarily a "problem of development," but essentially not a "problem for development." Tol and Leek (1999) also found positive impacts on GDP in the short term following a natural disaster, explaining that the disaster destroys the capital stock and increases the flow of new production.

results from the high investment in fixed capital. The paper also argued that the short-term negative impacts depended on the scale of the disasters (e.g. the loss-to-GDP ratio). Hochrainer studied the counterfactual versus the observed GDP. He also examined the disaster impacts of factors such as vulnerability, hazard, and exposure of assets. He found that in the medium term (up to five years) natural disasters often lead to negative consequences. As these empirical studies show, views on the short- and middle-term impacts vary.

2.2 Long-term economic growth

Natural disasters can have long-term effects through various causal relations. Those causal relations include destruction of schools, the crowding out effect of reconstruction expenditure on private investment, worsening fiscal balance leading to inflation, and environmental damage to agriculture, fishing, and forestry (Rasmussen 2004).

Skidmore and Toya (2002) extended the short-term analysis to long-term economic impacts by examining the causal linkage among disasters. They counted the frequency of natural disasters from 1960-1990 across countries and pursued an empirical investigation.[3] Their regression found that climatic disasters have positive and statistically significant impacts on the growth of TFP (Total Factor Productivity). On the other hand, geological disasters are generally statistically insignificant.

The findings of Sawada, Bhattcharyay and Kotera (2011) are in line with Skidmore and Toya (2002); that is, that disasters have positive effects on economic growth, especially climatic disasters. They quantitatively assessed and compared various natural and man-made disaster impacts using 189 cross-country panel data from between 1968 and 2001. The empirical findings were as follows. First, in the short term all disasters had negative impacts on GDP per capita. This is particularly true of climatological disasters, conflicts and financial crises. Second, in the long term natural disasters had very strong positive impacts on the growth of GDP per capita. Sawada, Bhattcharyay and Kotera (2011)

3. They have three hypotheses. First, they stated that disaster risks could have both positive and negative ambiguous impacts. They argued that the impact could be negative by lowering the expectation on the rate of return on physical capital, but would also lead to increased investment to meet the needs of disaster management. Second, regarding human capital, they followed the endogenous growth theory (Lucas 1988; Azariadis and Drazen 1990). They argued that a low expected rate of return on physical capital could shift to a human capital increase, then to a higher rate of economic growth.

argued that this counterintuitive positive growth effect was a result of the "Schumpeterian" creative destruction process.

Contrary to the findings of Skidmore and Toya (2002) and Sawada, Bhattcharyay and Kotera (2011), the results of the research by Cuaresma et al. (2008) showed a different picture. They argued that the view expressed by Skidmore and Toya on "Schumpeterian" creative destruction is different from that of Schumpeter himself (1950). Schumpeter's view on creative destruction stressed the importance of "competition" in a perfectly functioning market as an engine for technological progress, but Skidmore and Toya use the same term as more literal interpretation only for technological replacement after a disaster. The paper tested the validity of the Schumpeterian view expressed by Skidmore and Toya by means of a gravity equation to examine the correlation between transfer of technology and disasters in developing countries in the long term. Cuaresma Hlouskova, and Obersteiner (2008) found that disasters are negatively correlated to the adoption of new technology from abroad, and only countries with a higher level of development benefit from the introduction of technology after disasters.

Similarly, Noy (2009) found that 1) the amount of property damage caused by disasters is a negative determinant of GDP growth and 2) there is no correlation between the number of victims (killed or affected) and growth of GDP. He studied the determinants of macroeconomic output decline, using a linear regression model approach, and found that countries with the following factors are resilient to initial disaster shocks and further worsening of the macroeconomy. The factors he discussed are 1) higher rate of literacy, 2) better institutions, 3) better per capita income, 4) higher degree of openness to trade, and 5) higher levels of government spending.

The other empirical study that argues that natural disasters have negative impacts on economic growth in the long term is Benson and Clay (2003), while World Bank (2003) and Rasmussen (2004) found that natural disasters have no significant impact on economic growth. Rasmussen studied several Caribbean islands. He found that developing countries tend to be affected the most by natural disasters. Small island states have a high frequency of natural disasters. The paper identified a median reduction of the growth rate of 2.2 percentage points in the year of the event, but found that the long-term effect of natural disasters was indeterminate.[4]

From this review of previous literature, we see that there is no consensus as to the macroeconomic impacts of disasters. There is a strong need for more empirical studies on the consequences. Accumulating this knowledge will certainly contribute to policy planning for recovery after a disaster. One of the common problems with previous literature is the treatment of data. Almost all of the previous literature uses the EM-DAT database constructed and maintained by the Centre for Research on the Epidemiology of Disasters (CRED).[5] The EM-DAT database is global, and contains natural disaster data from 1900 to the present. It seems, however, that past literature has failed to capture the heterogeneous characteristics of natural disasters. Most studies use the number of disasters in a country as an explanatory variable. Considering the nature of a disaster, its direct impacts are local rather than national. For example, Okinawa is far to the south of the Japanese mainland and is prone to experience more hurricanes than Tokyo. The case is similar for Hawaii and the USA. Hence, for empirical study, it seems to be more appropriate to use disaggregated data to capture the heterogeneous nature of disasters. For example, in the case of Japan, prefectural data on disasters is available. Utilizing these data, we are able to capture a better picture of the impacts.

Furthermore, most studies, like that of Skidmore and Toya (2002), analyse the correlation between the "number" of natural disasters and economic growth. Again, natural disasters have different effects depending on various conditions (e.g. an earthquake's magnitude). Therefore, rather than the number of disasters, it seems more appropriate to use data such as the total amount of damage and the number of victims to capture the real impacts, because the number of people affected indicates the direct impacts of the disaster.[6]

4. Rasmussen (2004) provides a box reviewing studies on the macroeconomic implications of natural disasters such as 1) an immediate decrease in economic output; 2) a worsening of external balance; 3) deterioration in fiscal balances; and 4) poverty increase.

5. According to the CRED homepage, the database is compiled from various sources such as UN agencies, NGOs, insurance companies, research institutions, and press agencies.

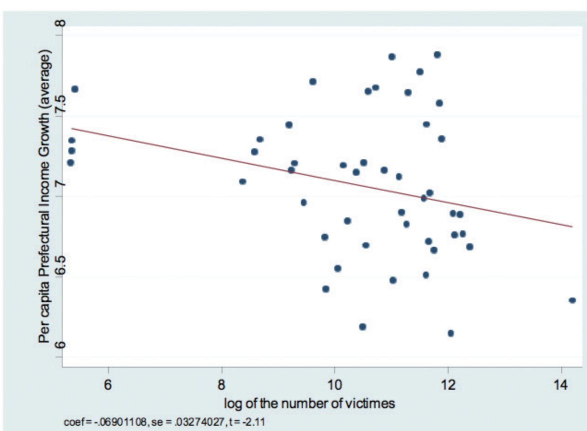
6. Noy (2009) disaggregated the EM-DAT data by region. He found that island countries are on average twice as vulnerable to disasters as other countries.

3. Initial evidence on disasters and economic growth

Before going into detail, this paper will present an initial analysis using a simple correlation between disasters and long-term economic growth for the 47 prefectures of Japan using the same analytical framework as Skidmore and Toya (2002) (Figure 2). The vertical axis shows the average annual per capita growth rate over the 1970–98 period. The horizontal axis measures the likelihood of a natural disaster. Skidmore and Toya presented the relationship between the total number of disasters and per capita GDP growth. As discussed above, instead of the number of disasters, in this paper the natural log of the number of victims was used as a better indicator to grasp the impact of natural disasters.[7]

This regression line shows a statistically significant negative correlation between the number of victims and economic growth. The coefficient is -0.069. This seems to be very small, but the absolute value of the coefficient is still greater than that of Skidmore and Toya (2002), which is 0.0033. On the basis of this number they argued that disasters have positive impacts. Naturally, the impacts of a natural disaster on economic growth are small, but this estimate is statistically robust.

Figure 2. Per capita prefectural income growth and disaster



Source: Author's calculation.

7. This paper uses absolute figures rather than relative figures. The previous literature uses both. This is because absolute figures sometimes capture the real impact of a natural disaster better. Furthermore, past studies, such as Skidmore and Toya (2002), examined the impact using both relative and absolute figures, and found the same results each time.

4. Data

For more detailed empirical analysis, this paper used the variables listed in Table 1. The definitions and data sources are also listed in Table 2. As discussed in the literature review section, this paper uses prefectural disaster data. The database is unbalanced panel data, covering all 47 Japanese prefectures for twenty years from 1975–1995. The maximum amount of total damage is huge because of the Great Hanshin Awaji Earthquake in 1995.

On the other hand, there is no prefectural data available on the number of disasters to actually hit a prefecture classified into geophysical disasters, meteorological disasters, and hydrological disasters. Therefore, unlike other past studies, this paper will not compare the impacts of each class of disaster. Furthermore, past studies differentiated between rich and poor countries, but in the case of Japan the gap between prefectures is small, and in many cases people can easily move from one prefecture to another. Therefore, this paper will not classify prefectures into income groups.

Table 1: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
GPDP	1128	7,560,000,000,000	10,900,000,000,000	667,000,000,000	86,100,000,000,000
Pgex	1360	656,000,000	761,000,000	46,600,000	7,030,000,000
Pgexrcv	1360	8365957	8,859,131	19,000	124,000,000
Tot_damage	1340	373,000,000,000	4,220,000,000,000	1,000,000	137,000,000,000,000

Source: Author's calculation.

Table 2: Definitions and sources of variables

Variable	Description	Source
GPDP_r	Growth of gross prefectural domestic product (at current price)	Cabinet Office, Government of Japan
Pgex_r	Growth of prefectural government expenditure	Ministry of Internal Affairs and Communication (Chihou Zaisei Nenpou)
Privtcapstx_r	Growth of prefectural private capital stock	Takero Doi (2002)
Tot_damage	Total amount of prefectural damage in Japanese Yen	White paper by the Fire Defense Agency (each year)

Source: Author's calculation.

5. Methodology

In order to set the stage for the analysis, this section presents an analytical framework for empirical analysis, which modifies the model of Noy (2009) and Noy and Vu (2010).

$$\log \Delta Y_{i,t} = \alpha_i + \beta \log \Delta Y_{i,t-1} + \gamma \log Dis_{i,t-1} + \mu \Delta \log X_{i,t,.} + \varepsilon_{i,t}$$

where $\Delta Y_{i,t}$ is the annual GDI (Gross Domestic Income) growth rate. *i* is a prefectural index to capture prefecture-specific effects, and *t* is the time index. $Dis_{i,t-1}$ is the measure for disaster magnitude, estimated by the amount of direct damage. Since disaster affects the following year, this is the disaster lag variable. $\Delta X^{1}_{i,.}$ is control lagged variables (such as growth of prefectural government expenditure and growth of prefectural private capital stock). This model includes a GDI growth lag following Islam (1995).

Islam (1995) also stated that a time span of just one year is too short because the short-term business cycle may influence the estimation results over such brief spans, so he proposed five-year time intervals. This is because his study focused on convergence. Unlike literature on convergence, the impacts of external shocks such as disasters differ year by year, especially during the first several years. Hence, instead of five-year time intervals, this paper employs annual data.

The lagged dependent variable might correlate with the error term. If this is the case, the conventional panel data analysis methods (pooling cross-sections across time, fixed effects, and random effects) are not consistent. These estimators are consistent only when all regressors are not correlated to the error term. In order to correct for the bias arising from the presence of a lagged dependent variable, this paper also employs the Prais-Winsten estimation, PCSE (panel-corrected standard error), and the system General Method of Moments (GMM) estimator (Noy and Vu 2010; Roodman 2003). The Prais-Winsten estimation is a method of multiple linear regression with AR(1) and exogenous explanatory variables. The Prais-Winsten standard errors account for serial correlation; the OLS standard errors do not. The PCSE (panel-corrected standard error) handles the issue of cross-section heteroskedasticity (Beck and Katz 2004). The presence of heteroskedasticity makes the OLS standard errors inconsistent. PCSE improves on OLS standard errors with respect to panel heteroskedasticity, but not other issues. The system GMM is used to tackle other possible biases by endogeneity and omitted variables in addition to the bias. Arellano and Bond (1991) first established the "difference-GMM" estimator for dynamic panels (Roodman 2003). Arellano and Bond's estimation starts by transforming all regressors, by differencing, and uses the GMM. The method regards lagged dependent variables as not exogenous and predetermined. A problem with the original Arellano–Bond difference-GMM estimator is that if there is an issue of a random walk of endogenous variables, the estimation becomes a biased coefficient estimation.

To tackle the above problem, Blundell and Bond (1998) articulated an improvement on augmented difference GMM by Arrelano and Bover (1995), adding more assumptions that the first difference of instrument variables are uncorrelated with the fixed effects, allowing more instruments to be introduced and making them exogenous to the fixed effects. The augmented estimator is called "system GMM." The command xtabond2 implements both estimations by Stata. The major advantage of the system GMM estimation, compared with the di□erence GMM, is that this approach effectively controls for autocorrelation and heteroskedasticity.

The system GMM estimation corrects for omitted variable bias by eliminating fixed effects through first-differencing, and for endogeneity bias using lagged endogenous regressors as effective instruments. In our system of GMM estimation, the lagged dependent variable is considered to be endogenous. This paper employs one-step estimation and implements the Hansen test to verify whether the instruments really satisfy the orthogonality condition (uncorrelated with the error term), and also implements the AR(1) and AR(2) test for autocorrelation.

6. Estimation results: The impacts on economic growth

The results are presented in Tables 3, 4, 5, 6, 7, 8 and 9. Each table shows the results from a different time lag of *tot_damage*, starting from 1 year to 20 years. As Table 3 shows, the F-test result (Prob>F=0.6189) indicates that the pooling model is more appropriate than the fixed effects estimation. Considering this, the Breusch and Pagan test and the Hausman test were implemented. The Breusch and Pagan test result (Prob > chibar2 =1.0000) indicates that the pooling regression model is more appropriate than the random-effects model. The Hausman test result (Prob>chi2 = 0.0000) means the fixed effects model is better than the random effects model. These three tests confirm that the pooling is the most suitable.

According to pooling, random effect, and fixed effect estimates, the results became significantly negative in years 3, 5, 6, 9, 10, 11 and 15. In these years, all three estimations returned the same results. In addition, fixed effect estimation returned statistically negative results in years 12 and 14. In sum, the conventional panel data analyses show negative impacts of natural disasters not just in the short term but in the long term as well.

The results of the Prais-Winsten estimation agreed, finding statistically negative results in years 1, 3, 4, 5, 6, 7. 8. 9, 10, and 11.[8] The negative impacts of natural disasters further were confirmed by the PCSE estimation. All estimated results became significantly negative. Due to the unbalanced nature of the panel, results were estimated until the 16-year lag. The results of the system GMM confirmed the impacts. The results of the Hansen test, AR(1) and AR(2) imply that, in most cases, the instruments are orthogonal to the error term and the error term is not autocorrelated in the system GMM estimation. The system GMM results became negative and consistent all through the years.

7. Conclusion

This paper analysed the economic impacts of natural disasters by utilizing the 47 prefectural panel data of Japan for twenty years. What can we conclude from the empirical findings above? The initial empirical study of "average annual per capita growth rate over the 1970–98 period" and "natural log of the number of victims" showed a negative and statistically significant relationship. In the following detailed study, this paper employed the conventional panel data analyses (pooling, fixed effects, and random effects), Prais-Winsten and PCSE and the system GMM.

Unlike several previous studies, which found positive long-term effects of natural disasters, this paper found that the impacts of natural

8. The Prais-Winsten estimation did not estimate in year 16 because convergence was not achieved.

disasters measured by total value of damage on economic growth are robustly negative according to our analyses. This study indicates that the impacts from natural disasters are long lasting. This conclusion is concurrent with what happened to the city of Kobe, one of major cities of Japan, after the earthquake in 1995 (Shimada 2014 and forthcoming). The economic gap between Kobe and the rest of Japan widened until 2003, and then after 2004, the economic trend in Kobe equalled that of the rest of Japan, but the city still has not totally 'filled the gap'. As the impacts are long lasting, it seems necessary to consider proactive recovery policies, not only short-term but also long-term.

As we showed, most previous literature used cross-country data of the number of natural disasters, and failed to capture the heterogeneous nature. As this study showed, it seems to be more appropriate to use disaggregated data. The findings of this paper are specific to Japan. In the future, more analysis using this kind of disaggregated data will be necessary from other regions and countries especially in developing countries where natural disasters hit harder than in developed countries. Further, it will be desirable to control other factors, which effect on economic growth other than natural disasters.

Table 3. Estimation result 1

Dependent Variable : Growth of gross prefectural domestic product

	Pooled	Random Effect	Fixed Effect	prais-winsten	PCSE	System GMM one step
Log (Growth of gross prefectural domestic product) (Lagged)	0.2466	0.2466	0.1883	0.4321	0.2606	0.1632
	[6.77]***	[6.77]***	[4.93]***	[12.49]***	[3.74]***	[2.69]***
Log (growth of prefectural government expenditure)	0.1526	0.1526	0.1468	0.1335	0.1476	0.1062
	[4.91]***	[4.91]***	[4.61]***	[4.48]***	[2.82]***	[3.45]***
Log (growth of prefectural private capital stock)	1.0098	1.0098	1.3818	0.7074	0.7171	0.864
	[7.84]***	[7.84]***	[8.91]***	[6.30]***	[5.42]***	[8.80]***
Log (Total amount of prefectural damage) (lagged 1 year)	-0.0212	-0.0212	-0.0108	-0.0287	-0.0429	-0.047
	[-1.63]	[-1.63]	[-0.63]	[-2.44]**	[-2.18]**	[-4.09]***
Log (Total amount of prefectural damage) (lagged 2 years)						
Log (Total amount of prefectural damage) (lagged 3 years)						
_cons	-0.7075	-0.7075	-1.3576	-0.3743		
	[-2.72]***	[-2.72]***	[-4.33]***	[-1.63]		
N	837	837	837	837	837	837
R-squared	0.2795		0.2767	0.4154	0.823	
Adj-R-squared	0.276		0.2307	0.4126		
AR (1)						0.001
AR (2)						0.332
Hansen Test						0.002
Breusch and Pagan Lagrangian multiplier test		Prob > chibar2 = 1.0000				0.426
F Test		Prob > F=0.6189				0.215
Hausman Test			Prob>chi2 = 0.0000			

	Pooled	Random Effect	Fixed Effect	prais-winsten	PCSE	System GMM one step
Log (Growth of gross prefectural domestic product) (Lagged)	0.2548	0.2548	0.1983	0.4224	0.2716	0.2219
	[7.06]***	[7.06]***	[5.25]***	[12.23]***	[5.48]***	[4.15]***
Log (growth of prefectural government expenditure)	0.1513	0.1513	0.1468	0.1347	0.1415	0.096
	[4.86]***	[4.86]***	[4.62]***	[4.49]***	[3.23]***	[3.06]***
Log (growth of prefectural private capital stock)	1.03	1.03	1.4237	0.7523	0.6751	0.7218
	[7.96]***	[7.96]***	[9.11]***	[6.59]***	[6.82]***	[8.50]***
Log (Total amount of prefectural damage) (lagged 1 year)						
Log (Total amount of prefectural damage) (lagged 2 years)	-0.006	-0.006	0.021	-0.013	-0.0357	-0.0277
	[-0.43]	[-0.43]	[1.13]	[-1.04]	[-2.41]**	[-2.86]***
Log (Total amount of prefectural damage) (lagged 3 years)						
_cons	-0.8927	-0.8927	-1.7341	-0.5817		
	[-3.30]***	[-3.30]***	[-5.20]***	[-2.41]**		
N	839	839	839	839	839	839
R-squared	0.2813		0.2819	0.4043	0.8223	
Adj-R-squared	0.2779		0.2363	0.4014		
AR (1)						0.001
AR (2)						0.354
Hansen Test						0.002
Breusch and Pagan Lagrangian multiplier test						0.377
F Test						0.215
Hausman Test						

	Pooled	Random Effect	Fixed Effect	prais-winsten	PCSE	System GMM one step
Log (Growth of gross prefectural domestic product) (Lagged)	0.2398	0.2398	0.1814	0.3747	0.2443	0.1955
	[6.68]***	[6.68]***	[4.83]***	[10.75]***	[6.75]***	[3.36]***
Log (growth of prefectural government expenditure)	0.1381	0.1381	0.1353	0.1262	0.1354	0.0985
	[4.47]***	[4.47]***	[4.27]***	[4.17]***	[3.65]***	[3.27]***
Log (growth of prefectural private capital stock)	0.9455	0.9455	1.2829	0.7572	0.8445	0.9498
	[7.39]***	[7.39]***	[8.29]***	[6.52]***	[10.52]***	[11.36]***
Log (Total amount of prefectural damage) (lagged 1 year)						
Log (Total amount of prefectural damage) (lagged 2 years)						
Log (Total amount of prefectural damage) (lagged 3 years)	-0.0556	-0.0556	-0.0691	-0.0456	-0.0636	-0.0696
	[-4.22]***	[-4.22]***	[-4.04]***	[-3.68]***	[-5.08]***	[-6.21]***
_cons	-0.2509	-0.2509	-0.6299	-0.2063		
	[-0.95]	[-0.95]	[-1.96]*	[-0.85]		
N	838	838	838	838	838	838
R-squared	0.295		0.2946	0.3829	0.8279	
Adj-R-squared	0.2916		0.2497	0.3800		
AR (1)						0.001
AR (2)						0.342
Hansen Test						0.002
Breusch and Pagan Lagrangian multiplier test						0.392
F Test						0.207
Hausman Test						

* p<0.1, ** p<0.05, *** p<0.01
Source: Author's calculation.

Table 4. Estimation result 2

Dependent Variable : Growth of gross prefectural domestic product

	Pooled	Random Effect	Fixed Effect	prais-winsten	PCSE	System GMM one step
Log (Growth of gross prefectural	0.242	0.242	0.1821	0.417	0.2512	0.2218
domestic product) (Lagged)	[6.51]***	[6.51]***	[4.64]***	[11.76]***	[5.85]***	[3.96]***
Log (growth of prefectural	0.1439	0.1439	0.1386	0.1265	0.1273	0.0870
government expenditure)	[4.50]***	[4.50]***	[4.22]***	[4.12]***	[3.73]***	[2.73]***
Log (growth of prefectural private	1.0463	1.0463	1.4139	0.7743	0.7229	0.7172
capital stock)	[8.18]***	[8.18]***	[9.14]***	[6.88]***	[9.12]***	[7.45]***
Log (Total amount of prefectural	-0.0126	-0.0126	-0.0059	-0.0143	-0.0393	-0.0255
damage) (lagged 4 years)	[-0.92]	[-0.92]	[-0.34]	[-1.13]	[-3.19]***	[-1.99]**
Log (Total amount of prefectural						
damage) (lagged 5 years)						
Log (Total amount of prefectural						
damage) (lagged 6 years)						
_cons	-0.832	-0.832	-1.4396	-0.5903		
	[-3.20]***	[-3.20]***	[-4.75]***	[-2.55]**		
N	835	835	835	835	835	835
R-squared	0.2757		0.274	0.3994	0.8212	
Adj-R-squared	0.2722		0.2277	0.3965		
AR (1)						0.001
AR (2)						0.325
Hansen Test						0.218

	Pooled	Random Effect	Fixed Effect	prais-winsten	PCSE	System GMM one step
Log (Growth of gross prefectural	0.2265	0.2265	0.159	0.3652	0.2271	0.1252
domestic product) (Lagged)	[6.32]***	[6.32]***	[4.26]***	[10.49]***	[5.45]***	[2.07]**
Log (growth of prefectural	0.1331	0.1331	0.1206	0.1218	0.1328	0.0926
government expenditure)	[4.33]***	[4.33]***	[3.86]***	[4.06]***	[4.70]***	[3.12]***
Log (growth of prefectural private	0.9914	0.9914	1.4202	0.783	0.9787	1.1605
capital stock)	[7.88]***	[7.88]***	[9.46]***	[6.87]***	[10.70]***	[8.30]***
Log (Total amount of prefectural						
damage) (lagged 4 years)						
Log (Total amount of prefectural	-0.0881	-0.0881	-0.1371	-0.0769	-0.0893	-0.1004
damage) (lagged 5 years)	[-5.72]***	[-5.72]***	[-6.55]***	[-5.39]***	[-6.07]***	[-4.64]***
Log (Total amount of prefectural						
damage) (lagged 6 years)						
_cons	-0.0335	-0.0335	-0.2372	0.0317		
	[-0.13]	[-0.13]	[-0.77]	[0.13]		
N	835	835	835	835	835	835
R-squared	0.3021		0.3105	0.3895	0.83	
Adj-R-squared	0.2987		0.2665	0.3865		
AR (1)						0.000
AR (2)						0.442
Hansen Test						0.215

	Pooled	Random Effect	Fixed Effect	prais-winsten	PCSE	System GMM one step
Log (Growth of gross prefectural	0.2354	0.2354	0.172	0.4045	0.2428	0.1486
domestic product) (Lagged)	[6.40]***	[6.40]***	[4.44]***	[11.48]***	[9.76]***	[2.41]**
Log (growth of prefectural	0.1478	0.1478	0.1402	0.1321	0.1435	0.1039
government expenditure)	[4.74]***	[4.74]***	[4.39]***	[4.39]***	[6.96]***	[3.24]***
Log (growth of prefectural private	1.0308	1.0308	1.4136	0.7761	0.7957	0.9332
capital stock)	[8.04]***	[8.04]***	[9.17]***	[6.83]***	[11.00]***	[8.59]***
Log (Total amount of prefectural						
damage) (lagged 4 years)						
Log (Total amount of prefectural						
damage) (lagged 5 years)						
Log (Total amount of prefectural	-0.0328	-0.0328	-0.039	-0.0286	-0.057	-0.0605
damage) (lagged 6 years)	[-2.04]**	[-2.04]**	[-1.72]*	[-1.96]**	[-4.71]***	[-4.20]***
_cons	-0.6286	-0.6286	-1.1402	-0.4622		
	[-2.33]**	[-2.33]**	[-3.50]***	[-1.92]*		
N	834	834	834	834	834	834
R-squared	0.2781		0.2762	0.3921	0.8226	
Adj-R-squared	0.2746		0.2299	0.3891		
AR (1)						0.001
AR (2)						0.347
Hansen Test						0.210

* p<0.1, ** p<0.05, *** p<0.01

Source: Author’s calculation.

Table 5. Estimation result 3

	Pooled	Random Effect	Fixed Effect	prais-winsten	PCSE	System GMM one step	Pooled	Random Effect	Fixed Effect	prais-winsten	PCSE	System GMM one step	Pooled	Random Effect	Fixed Effect	prais-winsten	PCSE	System GMM one step
Log (Growth of gross prefectural	0.2476	0.2476	0.1855	0.4095	0.2667	0.207	0.2225	0.2225	0.1521	0.3584	0.2412	0.182	0.2017	0.2017	0.1235	0.3361	0.2201	0.163
domestic product) (Lagged)	[6.84]***	[6.84]***	[4.89]***	[11.78]***	[9.28]***	[3.60]***	[5.90]***	[5.90]***	[3.81]***	[9.78]***	[7.50]***	[3.19]***	[5.19]***	[5.19]***	[3.00]***	[8.90]***	[12.14]***	[2.68]***
Log (growth of prefectural	0.1434	0.1434	0.1351	0.1291	0.1347	0.093	0.1219	0.1219	0.1122	0.1129	0.1156	0.080	0.0907	0.0907	0.0795	0.0863	0.0868	0.053
government expenditure)	[4.57]***	[4.57]***	[4.19]***	[4.25]***	[4.92]***	[2.87]***	[3.72]***	[3.72]***	[3.34]***	[3.51]***	[4.28]***	[2.54]**	[2.65]***	[2.65]***	[2.26]**	[2.56]**	[7.27]***	[1.63]
Log (growth of prefectural private	1.0424	1.0424	1.4235	0.7913	0.7279	0.814	1.1089	1.1089	1.5229	0.8917	0.7794	0.862	1.1628	1.1628	1.6343	0.9466	0.8709	0.924
capital stock)	[8.11]***	[8.11]***	[9.22]***	[6.93]***	[15.24]***	[9.04]***	[8.21]***	[8.21]***	[9.28]***	[7.24]***	[10.19]***	[9.18]***	[8.24]***	[8.24]***	[9.51]***	[7.31]***	[8.83]***	[8.95]***
Log (Total amount of prefectural	-0.0173	-0.0173	-0.0184	-0.0158	-0.047	-0.046												
damage) (lagged 7 years)	[-1.10]	[-1.10]	[-0.82]	[-1.11]	[-4.96]***	[-3.63]***												
Log (Total amount of prefectural							-0.02	-0.02	-0.0155	-0.02	-0.0515	-0.052						
damage) (lagged 8 years)							[-1.20]	[-1.20]	[-0.66]	[-1.30]	[-3.79]***	[-4.09]***						
Log (Total amount of prefectural													-0.0376	-0.0376	-0.055	-0.0383	-0.0643	-0.059
damage) (lagged 9 years)													[-2.20]**	[-2.20]**	[-2.28]**	[-2.41]**	[-3.68]***	[-3.91]***
_cons	-0.8039	-0.8039	-1.3574	-0.6078			-0.8421	-0.8421	-1.4883	-0.6555			-0.7294	-0.7294	-1.2767	-0.5376		
	[-3.04]***	[-3.04]***	[-4.29]***	[-2.57]**			[-3.06]***	[-3.06]***	[-4.60]***	[-2.60]***			[-2.57]**	[-2.57]**	[-3.86]***	[-2.05]**		
N	832	832	832	832	832	832	785	785	785	785	785	785	739	739	739	739	739	739
R-squared	0.2781		0.2793	0.3921	0.8202		0.2544		0.2542	0.3408	0.8054		0.2393		0.2395	0.3236	0.7925	
Adj-R-squared	0.2746		0.2331	0.3892			0.2506		0.2034	0.3374			0.2351		0.1843	0.32		
AR (1)						0.001						0.002						0.001
AR (2)						0.335						0.316						0.309
Hansen Test						0.208						0.201						0.220

* p<0.1, ** p<0.05, *** p<0.01
Source: Author's calculation.

Table 6. Estimation result 4

Dependent Variable: Growth of gross prefectural domestic product

	Pooled	Random Effect	Fixed Effect	prais-winsten	PCSE	System GMM one step	Pooled	Random Effect	Fixed Effect	prais-winsten	PCSE	System GMM one step	Pooled	Random Effect	Fixed Effect	prais-winsten	PCSE	System GMM one step
Log (Growth of gross prefectural	0.1762	0.1762	0.0974	0.2629	0.1958	0.129	0.1468	0.1468	0.0603	0.1152	0.1601	0.095	0.149	0.149	0.0471	-0.0677	0.1657	0.073
domestic product) (Lagged)	[4.37]***	[4.37]***	[2.30]**	[6.61]***	[4.82]***	[2.10]**	[3.52]***	[3.52]***	[1.36]	[2.75]***	[2.60]***	[1.46]	[3.34]***	[3.34]***	[1.00]	[-1.52]	[6.54]***	[1.06]
Log (growth of prefectural	0.0798	0.0798	0.0753	0.0781	0.0772	0.052	0.0655	0.0655	0.0608	0.0655	0.063	0.030	0.0506	0.0506	0.0415	0.0379	0.046	0.015
government expenditure)	[2.25]**	[2.25]**	[2.07]**	[2.21]**	[1.82]*	[1.61]	[1.79]*	[1.79]*	[1.61]	[1.79]*	[1.28]	[0.94]	[1.33]	[1.33]	[1.06]	[1.01]	[2.86]***	[0.49]
Log (growth of prefectural private	1.2223	1.2223	1.7231	1.0736	0.9351	1.070	1.1991	1.1991	1.6908	1.2517	0.9407	1.035	1.2127	1.2127	1.7851	1.5434	0.8997	[7.18]***
capital stock)	[8.09]***	[8.09]***	[9.48]***	[7.50]***	[10.63]***	[9.40]***	[7.66]***	[7.66]***	[8.88]***	[7.85]***	[11.35]***	[8.67]***	[7.24]***	[7.24]***	[8.81]***	[8.28]***	[8.59]***	
Log (Total amount of prefectural	-0.0483	-0.0483	-0.0869	-0.0488	-0.075	-0.087												
damage) (lagged 10 years)	[-2.68]***	[-2.68]***	[-3.42]***	[-2.84]***	[-4.72]***	[-4.88]***												
Log (Total amount of prefectural							-0.0457	-0.0457	-0.0711	-0.0455	-0.0712	-0.074						
damage) (lagged 11 years)							[-2.38]**	[-2.38]**	[-2.60]***	[-2.34]**	[-4.50]***	[-4.39]***						
Log (Total amount of prefectural													-0.0317	-0.0317	-0.0473	-0.0333	-0.0632	-0.073
damage) (lagged 12 years)													[-1.55]	[-1.55]	[-1.68]*	[-1.52]	[-3.34]***	[-3.03]***
_cons	-0.7134	-0.7134	-1.1406	-0.5722			-0.6598	-0.6598	-1.1703	-0.7096			-0.8039	-0.8039	-1.5132	-1.0651		
	[-2.28]**	[-2.28]**	[-3.09]***	[-1.93]*			[-2.00]**	[-2.00]**	[-3.01]***	[-2.11]**			[-2.24]**	[-2.24]**	[-3.59]***	[-2.70]***		
N	692	692	692	692	692	692	644	644	644	644	644	644	598	598	598	598	598	598
R-squared	0.2313		0.2393	0.2729	0.7769		0.2065		0.2044	0.1945	0.7585		0.1947		0.202	0.1372	0.7382	
Adj-R-squared	0.2269		0.18	0.2687			0.2015		0.1373	0.1895			0.1893		0.1291	0.1314		
AR (1)						0.002						0.007						0.005
AR (2)						0.304						0.325						0.409
Hansen Test						0.194						0.142						0.157

* p<0.1, ** p<0.05, *** p<0.01

Source: Author's calculation.

Table 7. Estimation result 5

Dependent Variable: Growth of gross prefectural domestic product

	Pooled	Random Effect	Fixed Effec	prais-winsten	PCSE	System GMM one step	Pooled	Random Effect	Fixed Effec	prais-winsten	PCSE	System GMM one step	Pooled	Random Effect	Fixed Effec	prais-winsten	PCSE	System GMM one step
Log (Growth of gross prefectural domestic product) (Lagged)	0.1493	0.1493	0.0425	-0.1	0.1745	0.094	0.1375	0.1375	0.0242	-0.0992	0.1682	0.100	0.1378	0.1378	0.0126	0.1917	0.1639	0.074
	[3.19]***	[3.19]***	[0.84]	[-2.13]**	[3.27]***	[1.32]	[2.82]***	[2.82]***	[0.46]	[-2.03]**	[2.72]***	[1.42]	[2.74]***	[2.74]***	[0.23]	[3.84]***	[3.00]***	[0.96]
Log (growth of prefectural government expenditure)	0.0571	0.0571	0.0438	0.0418	0.0552	0.025	0.0697	0.0697	0.0459	0.0517	0.0569	0.018	0.1057	0.1057	0.0671	0.1116	0.1018	0.062
	[1.42]	[1.42]	[1.05]	[1.06]	[0.94]	[0.78]	[1.53]	[1.53]	[0.98]	[1.17]	[1.00]	[0.51]	[2.15]**	[2.15]**	[1.31]	[2.26]**	[2.20]**	[1.60]
Log (growth of prefectural private capital stock)	1.2892	1.2892	1.8865	1.6759	0.8499	0.930	1.3217	1.3217	2.0062	1.7131	0.9095	1.006	1.2702	1.2702	2.0095	1.1713	0.8555	1.005
	[7.33]***	[7.33]***	[8.66]***	[8.52]***	[8.76]***	[7.67]***	[7.15]***	[7.15]***	[8.80]***	[8.29]***	[8.78]***	[7.03]***	[6.51]***	[6.51]***	[8.24]***	[6.18]***	[7.03]***	[7.05]***
Log (Total amount of prefectural damage) (lagged 13 years)	-0.0124	-0.0124	-0.012	-0.0034	-0.0563	-0.055												
	[-0.58]	[-0.58]	[-0.40]	[-0.15]	[-2.77]***	[-2.99]***												
Log (Total amount of prefectural damage) (lagged 14 years)							-0.0262	-0.0262	-0.0582	-0.0236	-0.0691	-0.072						
							[-1.14]	[-1.14]	[-1.81]*	[-0.96]	[-3.21]***	[-2.84]***						
Log (Total amount of prefectural damage) (lagged 15 years)													-0.0257	-0.0257	-0.0437	-0.0264	-0.0698	-0.080
													[-1.05]	[-1.05]	[-1.30]	[-1.10]	[-3.09]***	[-3.96]***
_cons	-1.1173	-1.1173	-1.9992	-1.5272			-1.0725	-1.0725	-1.8067	-1.4482			-1.08E+00	-1.08E+00	-1.98E+00	-9.78E-01		
	[-2.97]***	[-2.97]***	[-4.46]***	[-3.74]***			[-2.67]***	[-2.67]***	[-3.86]***	[-3.31]***			[-2.54]**	[-2.54]**	[-3.97]***	[-2.37]**		
N	558	558	558	558	558	558	517	517	517	517	517	517	482	482	482	482	482	482
R-squared	0.1964		0.2026	0.1375	0.7239		0.2059		0.2231	0.1612	0.7165		0.2067		0.2225	0.2312	0.6995	
Adj-R-squared	0.1906		0.124	0.1313			0.1997		0.1397	0.1546			0.2		0.1323	0.2248		
AR (1)						0.011						0.004						0.011
AR (2)						0.370						0.267						0.342
Hansen Test						0.079						0.206						0.146

* p<0.1, ** p<0.05, *** p<0.01
Source: Author's calculation.

Table 8. Estimation result 6

	Pooled	Random Effect	Fixed Effect	PCSE	System GMM one step	Pooled	Random Effect	Fixed Effect	prais-winsten	System GMM one step	Pooled	Random Effect	Fixed Effect	prais-winsten	System GMM one step
Log (Growth of gross prefectural domestic product) (Lagged)	0.118	0.118	-0.0068	0.1531	0.042	0.0975	0.0975	-0.0415	-0.2775	0.519	0.0969	0.0969	-0.0632	-0.2524	0.033
	[2.24]**	[2.24]**	[-0.12]	[4.80]***	[0.55]	[1.71]*	[1.71]*	[-0.67]	[-4.97]***	[0.66]	[1.59]	[1.59]	[-0.95]	[-4.20]***	[0.40]
Log (growth of prefectural government expenditure)	0.1219	0.1219	0.0841	0.1126	0.055	0.1142	0.1142	0.0696	0.0491	0.241	0.0998	0.0998	0.0589	0.0381	0.033
	[2.30]**	[2.30]**	[1.52]	[3.47]***	[1.37]	[2.04]**	[2.04]**	[1.18]	[0.96]	[0.57]	[1.65]	[1.65]*	[0.92]	[0.67]	[0.77]
Log (growth of prefectural private capital stock)	1.3256	1.3256	2.0471	0.8516	1.354	1.4871	1.4871	2.3084	2.1901	1.063	1.5602	1.5602	2.4188	2.1794	1.138
	[6.31]***	[6.31]***	[7.84]***	[5.97]***	[9.00]***	[6.40]***	[6.40]***	[7.97]***	[8.11]***	[8.04]***	[6.21]***	[6.21]***	[7.77]***	[7.42]***	[7.03]***
Log (Total amount of prefectural damage) (lagged 16 years)	-0.0232	-0.0232	-0.0494	-0.073	0.083										
	[-0.89]	[-0.89]	[-1.35]	[-2.81]***	[-4.86]***										
Log (Total amount of prefectural damage) (lagged 17 years)						-0.017	-0.017	-0.0529	-0.0151	-0.088					
						[-0.58]	[-0.58]	[-1.30]	[-0.49]	[-4.16]***					
Log (Total amount of prefectural damage) (lagged 18 years)											-0.0116	-0.0116	-0.0435	-0.0301	-0.108
											[-0.35]	[-0.35]	[-0.95]	[-0.86]	[-4.18]***
_cons	-1.22	-1.22	-2.0287			-1.5396	-1.5396	-2.4196	-2.2477		-1.7227	-1.7227	-2.6862	-2.1494	
	[-2.69]***	[-2.69]***	[-3.78]***	-		[-3.02]***	[-3.02]***	[-3.93]***	[-4.00]***		[-3.11]***	[-3.11]***	[-4.03]***	[-3.44]***	
N	437	437	437	437	437	394	394	394	394	394	350	350	350	350	350
R-squared	0.2075		0.2256	0.6754		0.2161		0.2475	0.1892		0.2204		0.2547	0.1978	
Adj-R-squared	0.2002		0.1253			0.208		0.1378	0.1808		0.2113		0.13	0.1885	
AR (1)					0.017					0.016					0.026
AR (2)					0.382					0.264					0.426
Hansen Test					0.117					0.073					0.053

Source: Author's calculation.

Table 9. Estimation result 7

	Pooled	Random Effect	Fixed Effect	prais-winsten	System GMM one step	Pooled	Random Effect	Fixed Effect	prais-winsten	System GMM one step
Log (Growth of gross prefectural domestic product) (Lagged)	0.0924	0.0924	-0.0675	0.2641	0.047	0.0576	0.0576	-0.0963	0.2733	0.0334
	[1.44]	[1.44]	[-0.92]	[4.21]***	[0.50]	[0.81]	[0.81]	[-1.20]	[4.01]***	[0.42]
Log (growth of prefectural government expenditure)	0.1371	0.1371	0.0979	0.1557	0.061	0.102	0.102	0.0384	0.112	0.0134
	[2.03]**	[2.03]**	[1.32]	[2.31]**	[1.16]	[1.37]	[1.37]	[0.46]	[1.51]	[0.25]
Log (growth of prefectural private capital stock)	1.5011	1.5011	2.2993	1.1347	0.943	1.4333	1.4333	2.2543	0.929	0.9764
	[5.66]***	[5.66]***	[6.67]***	[4.69]***	[5.22]***	[4.65]***	[4.65]***	[5.70]***	[3.37]***	[5.31]***
Log (Total amount of prefectural damage) (19 year lag)	0.0155	0.0155	0.0012	0.0149	-0.081					
	[0.42]	[0.42]	[0.02]	[0.44]	[-2.69]***					
Log (Total amount of prefectural damage) (20 year lag)						0.0016	0.0016	-0.0426	-0.0044	-0.0911
						[0.04]	[0.04]	[-0.69]	[-0.12]	[-2.81]***
_cons	-1.9553	-1.9553	-2.9552	-1.5617		-1.7103	-1.7103	-2.4644	-1.0749	
	[-3.47]***	[-3.47]***	[-4.35]***	[-2.98]***		[-2.61]***	[-2.61]***	[-2.97]***	[-1.83]*	
N	308	308	308	308	308	263	263	263	263	263
R-squared	0.2115		0.2352	0.2875		0.1546		0.1849	0.2131	
Adj-R-squared	0.2011		0.0864	0.2781		0.1415		-0.0074	0.2009	
AR (1)					0.022					0.017
AR (2)					0.365					0.214
Hansen Test					0.054					0.025

* $p<0.1$, ** $p<0.05$, *** $p<0.01$
Source: Author's calculation.

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