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Paper:

Estimating the Nankai Trough Megathrust Earthquake's Anticipated Fiscal Impact on Japanese Governments

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This study estimates the fiscal impact of the anticipated Nankai Trough Megathrust Earthquake on both the national and local Japanese governments to identify their sovereign risk. First, we estimate the impact of the Great East Japan Earthquake on local public finance using panel data regressions on 2008–2015 fiscal data. Second, based on the anticipated damage data – seismic intensity and area of inundation – of the Nankai earthquake and the coefficients derived from the first step, we estimate the amounts of fiscal revenue and expenditures that would be required by every local government for the anticipated Nankai earthquake. Finally, we estimate the fiscal expenditure of the national government in proportion to the estimated local ones. We find that first, the estimated fiscal requirements in the two years after the earthquake are about JPY 161 trillion, 5.9 times those of the 2011 Great East Japan Earthquake. Second, the financial disparity between affected and non-affected local governments is large because the Nankai earthquake would affect more municipalities than the Great East Japan Earthquake. The fiscal burden of non-affected municipalities would be relatively higher. These findings indicate that the Nankai earthquake will not only be a local disaster but also a national catastrophe.

Keywords: fiscal risk, disaster-related contingent liability, disaster recovery, Nankai Trough Megathrust Earthquake, Great East Japan Earthquake

1. Introduction

The fiscal risk to governments, especially in developing countries, from natural disasters has been widely recognized in the last decade. Traditional economic theory suggests that governments should ignore publicly borne risks because these can be distributed among a very large number of people [1]. However, this theory holds only if we assume that the government is risk-neutral. It does not hold for countries that are small or have high levels of debt and cannot efficiently pool risk [2]. Moreover, governments need to respond to calamities very quickly and may also face liquidity constraints [2, 3].

Considering these concerns, several studies have attempted to evaluate the fiscal risk of disasters. Cardona et al. [4, 5] developed the Disaster Deficit Index (DDI), which measures a country's disaster risk from a macroeconomic and financial perspective. There are several practices that national governments can engage in to mitigate future sovereign risk resulting from disasters. One of the most famous examples is FONDEN, a national fund for disaster response financed through capital markets using Catastrophe (CAT)-bonds. FONDEN was established by the government of Mexico, with support from the World Bank [6]. Other examples include multinational risk-pooling alliances, such as the Caribbean Catastrophe Risk Insurance Facility (CCRIF) and the African Risk Capacity (ARC), which were organized in 2007 and 2012, respectively. Along with these policy trends, the World Bank launched a study program on Sovereign Disaster Risk Financing and Insurance (SDRFI) and has been trying to promote the fiscal resilience of governments in cases of catastrophic disasters [7].

Almost all these endeavors focus on developing countries. Due to the relatively larger scale of their budget, developed countries are believed to be almost free from sovereign disaster risk. This might be true in general; however, several countries, such as Greece and Italy, have faced substantial sovereign risk, even without disasters. In addition, the economic cost of disasters is very large in developed countries due to the high value of the assets exposed to hazards. Hence, it is plausible that disaster damage could ignite a country's sovereign risk, causing a steep increase in the interest rates of public bonds, a sharp decrease in the value of its currency, and so on.

This study identifies the sovereign risk of both national and local Japanese governments. Japan is undoubtedly one of the countries that face disaster-induced sovereign risk. At more than 200% of its national Gross Domestic Product (GDP), its accumulated governmental debt is at a high level. Further, there is a high probability of large-scale earthquakes and tsunamis occurring in the western part of the country or even in Tokyo. In addition, Gamper et al. [8] referred to Japan as one of the countries that have

a high "government contingent liability," which refers to a government's fiscal obligations that are triggered when an uncertain future event occurs. Furthermore, they emphasized the importance of managing disaster-related contingent liabilities. Considering this concern, this study examines the effects of the Nankai Trough Megathrust Earthquake on public finance in terms of revenue and spending, using fiscal data of local governments from the period when the Great East Japan Earthquake occurred.

The Nankai Trough Megathrust Earthquake (hereinafter, the "Nankai earthquake") is an earthquake that has been anticipated by the Cabinet Office of the Japanese Government since 2013. It is assumed that the magnitude of the earthquake would be as high as 9.1 on the Richter scale, which is regarded as possibly the largest earthquake in the Nankai Trough. The tremors of the earthquake are supposed to hit the western part of Japan, and the tsunami generated by it is also supposed to hit the pacific coast of western Japan, causing more than 300,000 deaths. Total direct economic losses are estimated to be as high as USD 1.56 trillion (JPY 171.6 trillion) in the worst case scenario, more than five times those of the Great East Japan Earthquake. As such, the earthquake, along with the Tokyo inland earthquake that will directly hit the Tokyo metropolitan area, is often cited by stakeholders of disaster management in Japan as likely to be one of the worst national catastrophes.

This paper is organized as follows. Section 2 describes the fiscal impact of the 2011 Great East Japan Earthquake on Japanese governments and the institutional arrangement that enabled these governments to handle the huge expenditure it required. Section 3 explains the model and estimation method, while Section 4 describes the data used. Section 5 presents the results of the analysis. Lastly, Section 6 provides the conclusions and lists future challenges.

2. Institutional Arrangement for Financing Disaster Recovery of Local Governments

The Great East Japan Earthquake of 2011 caused the most extensive devastation in Japan since World War II. The economic cost was estimated by the Cabinet Office to be as high as USD 153 billion (JPY 16.9 trillion) using the exchange rate as of March 2011. This does not include the costs of the Fukushima Daiichi Nuclear Power Plant accident. The Japanese government devoted huge financial resources to the disaster recovery process, including reconstruction of damaged infrastructure, construction of new mitigation facilities, provision of housing and livelihood support to the affected population, and cleaning up of the land contaminated by radionuclides. The total amount on the reconstruction and recovery during the initial five years was estimated by Sato and Miyazaki [9] to be as high as USD 257 billion (JPY 28.3 trillion). Although the actual total cost is still unclear, the government announced that about JPY 25 trillion was planned for the initial five years of recovery, which is almost 25% of the total annual budget of Japan's national general account.

There were two major challenges with regard to public finance that the Japanese government faced during the various phases of recovery. One of these was how to finance the very large recovery burden. Government-issued bonds are usually a major source of revenue for coping with unexpected fiscal demands. However, there were grave doubts about credibility of Japanese Government Bond if all the necessary bonds were issued in one go, without any institutional guarantee for redemption. Thus, the Reconstruction Design Council, established by the Prime Minister of Japan as an advisory board for disaster recovery policy, recommended a temporary increase in taxes for the purpose of reconstruction [10].

The second challenge was how to financially support the affected local governments. Japan has two layers of local governments. The first one, at the prefecture level, is formed by 47 prefectural governments. The second is at the municipality level, consisting of 1,727 municipal governments. The national government, as well as the two layers of local governments, is responsible for disaster management. Prefectures, as well as the national government, shoulder most of the responsibility for building disaster-resilient infrastructure such as roads and bridges, river management, and ports and coastal structures. The municipalities provide resident-oriented services, such as water and sewage, schools and hospitals, social welfare services, disaster relief, and individual assistance. During the recovery phase, under the Japanese disaster management system, the national government, instead of the local governments, is basically expected to cover a certain portion of the reconstruction cost as "specific-purpose grant," both in the prefecture and municipality levels. The portion varies depending on the type of assets to be reconstructed – roughly 60% to 80% for local infrastructure, 50% to 66% for public facilities such as public housing and facilities for welfare institutions, and 80% for farmland and farming facilities. Moreover, the local government is supposed to cover the rest of the reconstruction cost. However, in case of a catastrophic disaster with damage far greater than the tax revenue of the affected local government, the Cabinet is expected to designate the disaster as a "extremely sever disaster." This expands the burden of the national government 10% to 20% higher than the original subsidy rate. In any case, it should be noted that the local government can issue public bonds to cover the infrastructure reconstruction cost, and 95% of it would be reimbursed later through "Local Allocation Tax (LAT)" grants that are general-purpose intergovernmental fiscal transfers from the national government to local governments.

However, in spite of these institutional arrangements, the local governments hit by the 2011 earthquake and tsunami in Tohoku were deemed to suffer from a lack of financial sources, owing to both the severity of the damage and the scarcity of tax revenues. To cope with the situation, the Japanese government expanded the target reconstruction project and raised the national coverage rate of special purpose grants to a maximum of 90%. It passed

the "Special Law for Financial Aid for the Great East Japan Earthquake" in May 2011. The project included reconstruction of drainage systems, waste disposal, and temporary office buildings for local governments. In addition, the national government allowed 95% to 100% of the reconstruction cost to be covered by local governments through LAT grants. This meant that some local governments, which received local tax grants amounting to 100% of their coverage, could undertake major reconstruction projects without any financial burden.

Partly because of such extraordinary financial arrangements, some studies have challenged the disaster recovery policy of the Japanese government. For example, Matanle [11] pointed out that the infrastructure reconstructed was excessive, as it ignored the declining and aging population. Cho [12] also argued that the reconstruction grants from the national government deprived local governments of their discretion regarding physical infrastructure projects. However, we assume that recovery from the next big earthquake disaster will be undertaken under the existing system, because no alternative systems that improve the recovery process have been established yet.

3. Methodology

The analysis follows a two-step procedure. First, the impact of the Great East Japan Earthquake on local public finance is estimated using panel data regressions on fiscal data for the period 2008–2015. Second, by employing anticipated-damage data – seismic intensity and area of inundation – of the Nankai earthquake and the coefficients estimated in the first step, the amounts of fiscal revenue and expenditures required for the Nankai earthquake are calculated for each of the local governments. The fiscal effects of the earthquake are calculated at both the prefecture and municipality levels.

3.1. Estimation of Revenue and Expenditure Functions of Local Governments

Revenue and expenditure functions are estimated separately, and both are further categorized into more detailed budgetary items. For municipality data, revenues are classified into local inhabitant taxes for individuals and corporations, property taxes, debt, ordinary and specific LATs, and specific-purpose grants (grants from national and prefecture governments). Meanwhile, revenues for prefecture data are classified into local taxes, debt, ordinary and specific LATs, and specific-purpose grants. For both municipality and prefecture data, expenditures consist of personnel, material (contracting-out and travel costs), maintenance, public assistance (including child welfare and livelihood protection), subsidy, ordinary construction (necessary for the construction of infrastructure such as roads, bridges, parks, and schools), and recovery from disaster expenses, as well as the accumulated fund. Categorized revenue and expenditure items are adopted for regressions and are aggregated to quantify total values because regressions of overall revenue and expenditure may not yield properly fitted values for the simulation of the Nankai earthquake.

We begin with the municipal-level model. For municipalities, the sample and regressions are split based on the status of the disaster damage, that is, devastated or non-devastated. The reason for the split is that the effects of socioeconomic and demographic variables on per capita budgetary item spending are believed to differ between affected and non-affected municipalities. We regress the logs of these budgetary items on earthquake-damage and socioeconomic variables. The regression function is expressed as:

$$\ln(Y_{it}) = \sum_{j=1}^{5} \alpha_j INUND_i \cdot DUMMY_j + X_{it}\gamma + c_i + \tau_t + \varepsilon_{it} \quad i = 1,\ldots,N,\ \ t = 2008,\ldots,2015, \qquad (1)$$

where Y_{it} denotes per capita budgetary items and X_{it} is a vector denoting the controls. The variables shown with $INUND$ are the earthquake damage variables, which are our primary interest, and they represent the fraction of the inundated area (as caused by the earthquake) to the total for the municipalities. The variable $DUMMY_j$ denotes year dummy variables that take the value of one in the year $2010+j$ and zero otherwise. Therefore, the parameter α_j captures the impact of the disaster on the budgetary items over five years. The contents of X_{it} depend on whether Y_{it} is a revenue or expenditure item. In the revenue functions, X_{it} includes the log of the population and the proportions of workers in the manufacturing and service industries as controls; its coefficient is γ. In the expenditure functions, X_{it} includes the proportion of ordinary LAT and specific-purpose grants to total revenue, and the log of accumulated debt, as well as the log of the population and proportion of workers in the manufacturing and service industries. In the prefecture-level regressions, the log of accumulated debt is omitted from the controls. As for the remaining controls, c_i stands for individual dummies and τ_t for year dummies, both of which are assumed to be constant, respectively over individual and over time, in our analysis. Our empirical models are estimated using fixed effects regressions. The term ε_{it} is the ordinary error term. The number of cross-sections is denoted as N.

For prefectures, the sample is not divided because the prefecture sample size is small and dividing the sample might negatively affect the performance of the regressions. Instead, the variables that indicate what proportion of municipalities was affected are included among the explanatory variables. The regression equation is:

$$\ln(Y_{it}) = \sum_{j=1}^{5} (\alpha_j INUND_i + \beta_j AFFECTED_i) \cdot DUMMY_j + X_{it}\gamma + c_i + \tau_t + \varepsilon_{it}, \quad i = 1,\ldots,47,\ \ t = 2008,\ldots,2015, \qquad (2)$$

where $AFFECTED_i$ represents the degree of the disas-

ter's impact on prefecture i, defined as the ratio of the number of designated municipalities under the Disaster Relief Act of Japan to the total number of municipalities. In this model, the disaster impact can be identified with two parameters – α_j captures the impact of inundation, whereas β_j captures the impact of disaster relief.

3.2. Calculation of Revenue and Expenditure for the Nankai Earthquake

The coefficients estimated from the regressions are used to predict the fiscal amounts required for the Nankai earthquake. The coefficients used for the calculation are α_j and β_j for $j = 1,2,\ldots,5$ and τ_t. Since the dependent variables are used here in log form, the coefficients obtained represent their growth (change) rates. Then, for both municipality and prefecture i, the increment of each budgetary item in the j-th year after the disaster is expressed as:

$$(\hat{\alpha}_j \times NANKAIINUND_i) \cdot Y_{ij} \quad \ldots\ldots\ldots \quad (3)$$

and

$$(\hat{\alpha}_j \times NANKAIINUND_i + \hat{\beta}_j \times NANKAIDUM_i + \hat{\tau}_{2010+j}) \cdot Y_{ij}, \quad \ldots \quad (4)$$

respectively, where $NANKAIDUM_i$ is a dummy for the affected municipalities. It is defined as municipalities that will experience tremors higher than upper level 5 on the Japanese seismic intensity scale if the Nankai earthquake happens. $NANKAIINUND_i$ denotes the ratio of the inundated area to the total area. Therefore, τ_{2010+j} stands for the coefficients of the time dummies that correspond to those for the j-th year after the disaster. For example, τ_{2011} is the coefficient of the year dummy for 2011. $\hat{\alpha}$, $\hat{\beta}$, and $\hat{\tau}$ denote estimated values of α, β, and τ respectively. As the Great East Japan Earthquake occurred in FY2010,[1] Eqs. (3) and (4) represent the amounts of fiscal revenue and expenditure for the Nankai earthquake in the j-th year after the earthquake for municipalities and prefectures, respectively. In these calculations, the coefficients in Eqs. (1) and (2) that are not significant at the 10% level in the regressions are replaced by a zero coefficient. In other words, we do not count the effects of insignificant coefficients.

We calculate total revenue and expenditure for each municipality affected by the earthquake by aggregating the amounts of every relevant budgetary item and excess expenditures for the earthquake as expenditure minus revenue. In the same way, increments in local taxes are quantified as the sum of the increments in local inhabitant taxes for individuals and corporations plus property taxes. The increments in intergovernmental transfers are quantified as the sum of ordinary and specific LATs and specific-purpose grants. For prefectures, $NANKAIDUM_i$ is replaced by the fraction of municipalities that are expected to experience seismic scale levels higher than 5 during the Nankai earthquake.

1. The Japanese fiscal year begins on April 1 and ends on March 31. Since the Great East Japan Earthquake happened on March 11, 2011, it belonged to FY2010.

4. Descriptive Statistics

Table 1 provides the descriptive statistics of the budgetary items and explanatory variables for municipalities and prefectures. The sample for municipalities is divided into affected and non-affected municipalities. All datasets are panel data over the years 2008–2015. As shown in the tables, the standard deviations of ordinary and specific LAT and expenses for disaster recovery are larger for the municipalities than for the prefectures. One reason for the large variation in the two LATs is that several of the wealthier municipalities do not receive LAT, which is aimed at providing grants for poor municipalities. The expenses on disaster recovery vary significantly because this type of spending depends on the severity of the damage. As shown in **Table 1**, $INUND$ exhibits large variation, with the coefficient of variation exceeding nine in a fraction of the inundated areas among the municipalities, at a maximum value of around 50%. Turning to prefectures, $AFFECTED$ shows that on average, 0.6% of municipalities are designated as affected by the Great East Japan Earthquake, but the maximum percentage of municipalities affected within a prefecture is around 60%. In addition, the maximum percentage of areas inundated is 4.5%.

5. Results

5.1. Regression Results

Table 2 presents the estimation results of the revenue and expenditure functions of each budgetary item for municipalities and prefectures from 2008 to 2015. As seen in **Table 2**, the affected municipalities with large inundated areas faced significant reductions in inhabitant taxes for individuals and in property taxes in 2011 and 2012. The inhabitant tax for corporations in the affected municipalities decreased in 2011 but increased in 2012 and 2013. This was probably due to the recovery and reconstruction projects in the affected areas. By contrast, the amounts of debt and ordinary LAT per capita did not show a significant change after the disaster. Among the intergovernmental grants, specific LAT and specific-purpose grants increased dramatically, with increases witnessed in inundated areas from 2011 onward. The signs of the coefficients of year dummies after the earthquake for local taxes in the affected and non-affected municipalities are the opposite of each other. Specifically, in 2011, the signs for inhabitant taxes and for individual and property taxes for non-affected areas were positive but negative for affected areas.

Table 3 displays the regression results of the expenditure items related to municipalities. It is interesting to see that the coefficients of $INUND_i \cdot DUMMY_j$ on "Spend-

Table 1. Descriptive statistics.

	Non-Affected Municipalities					Affected Municipalities					Prefectures				
	Mean	SD	Max	Min	NOB	Mean	SD	Max	Min	NOB	Mean	SD	Max	Min	NOB
A. Budgetary Items of Revenue															
Inhabitant tax for individual, pc ('000 Yen)*	42.2	17.5	309.6	14.1	12,514	36.5	12.4	116.5	4.4	1,488	111.5	39.9	421.8	69.5	376
Inhabitant tax for corporation, pc ('000 Yen)	9.2	13.1	482.3	0.0	12,514	9.8	9.2	134.5	1.4	1,488					
Property tax, pc ('000 Yen)	64.5	69.7	1727.1	0.0	12,514	71.8	76.7	954.6	1.0	1,488					
Debt, pc ('000 Yen)	61.2	69.4	2954.1	0.0	12,514	50.5	50.3	793.1	0.0	1,488	65.5	21.1	185.3	11.6	376
Ordinary LAT, pc ('000 Yen)	204.3	235.9	2952.6	0.0	12,514	157.2	145.8	1187.2	0.0	1,488	107.7	58.6	260.0	0.0	376
Specific LAT, pc ('000 Yen)	29.1	49.0	920.1	0.0	12,514	20.2	28.3	460.6	0.2	1,488	2.4	3.9	46.5	0.0	376
Specific-purpuse grant, pc ('000 Yen)	123.8	186.2	9187.9	20.6	12,514	229.7	538.1	7916.1	22.2	1,488	72.0	49.7	563.3	19.5	376
B. Budgetary Items of Expenditure															
Personnel expense, pc ('000 Yen)	102.8	71.4	927.4	31.3	12,514	90.5	48.0	596.5	38.6	1,488	121.8	19.1	168.4	76.5	376
Material expense, pc ('000 Yen)	84.7	89.1	2239.2	21.3	12,514	106.2	160.7	2440.0	21.4	1,488	15.9	8.7	93.0	6.4	376
Maintenance expense, pc ('000 Yen)	8.1	15.1	463.7	0.0	12,514	7.3	9.8	134.3	0.0	1,488	4.0	2.8	13.9	0.3	376
Public assistance expense, pc ('000 Yen)	62.4	25.4	206.2	8.0	12,514	54.1	23.9	343.5	9.9	1,488	9.0	3.6	18.4	3.4	376
Subsidy expense, pc ('000 Yen)	73.6	60.5	783.9	7.6	12,514	72.3	74.8	1279.0	8.0	1,488	89.3	30.0	307.0	49.8	376
Ordinary construction expense, pc ('000 Yen)	114.4	201.6	9321.7	2.2	12,514	126.5	238.6	4428.8	1.3	1,488	75.0	34.2	182.0	13.6	376
Expenses for recovery from disaster, pc ('000 Yen)	4.8	25.4	1251.7	0.0	12,514	24.4	66.2	974.3	0.0	1,488	4.5	13.8	152.8	0.0	376
Accumulated fund, pc ('000 Yen)	60.5	40.8	912.2	10.3	12,514	59.0	39.6	478.3	16.7	1,488	1.7	1.9	16.4	0.0	376
C. Explanatory Variables															
AFFECTED											0.006	0.050	0.592	0.000	376
INUND, %	0.0	0.1	5.0	0.0	12,514	0.3	2.9	47.8	0.0	1,488	0.018	0.237	4.488	0.000	376
Population	74171	188149	3647934	157	12,514	55011.1	99110.9	1045205	586	1,488	2714952	2631409	13415349	579309	376
Fraction of workers for the manufucture industry, %	26.5	8.4	52.9	1.3	12,514	30.1	6.6	47.5	3.7	1,488	25.2	5.0	34.8	14.0	376
Fraction of workers for the service industry, %	61.4	10.4	92.6	20.5	12,514	57.1	10.4	93.4	29.8	1,488	65.0	4.2	77.4	57.0	376
Ratio of ordinary LAT to revenue, %	25.8	15.4	66.3	0.0	12,514	22.9	13.9	61.3	0.0	1,488	22.2	8.9	39.7	0.0	376
Ratio of specific grant to revenue, %	18.1	6.0	68.0	2.6	12,514	22.1	11.9	90.1	5.9	1,488	14.7	4.9	49.1	5.2	376
Accumulated debt, pc ('000 Yen)	636.9	545.5	9834.7	1.7	12,514	500.6	271.8	3599.9	1.5	1,488					

Note: SD represents standard deviation. "pc" is an abbreviation of "per capita;" "LAT is an abbreviation of "Local Allocation Tax."
* this row represents "Local tax pc." for prefecures.
Source: MIC [13,14].

Table 2. Regressions of revenue items for municipalities over the period 2008–2015.

	Non Affected Municipalities							Affected Municipalities						
Dependent Var (in log form)	Inhabitant tax for individual	Inhabitant tax for corpo-ration	Property tax	debt	Ordinary LAT	Specific LAT	Specific-purpuse grant	Inhabitant tax for individual	Inhabitant tax for corpo-ration	Property tax	debt	Ordinary LAT	Specific LAT	Specific-purpuse grant
INUND · DUMMY_1	0.002	-0.010	-0.005	-0.049	-0.025	0.077***	0.049*	-0.005***	-0.005**	-0.011***	0.006	-0.002	0.039***	0.050***
	(0.006)	(0.025)	(0.007)	(0.050)	(0.032)	(0.016)	(0.026)	(0.001)	(0.003)	(0.002)	(0.005)	(0.003)	(0.005)	(0.005)
INUND · DUMMY_2	0.001	0.019	-0.005	-0.043	-0.034	0.053***	0.057**	-0.004***	0.005*	-0.006***	-0.005	-0.001	0.060***	0.068***
	(0.006)	(0.025)	(0.007)	(0.050)	(0.032)	(0.016)	(0.026)	(0.001)	(0.003)	(0.002)	(0.005)	(0.003)	(0.005)	(0.005)
INUND · DUMMY_3	0.000	0.038	-0.002	-0.020	-0.030	0.007	0.062**	-0.002	0.006**	-0.003*	0.000	-0.001	0.053***	0.051***
	(0.006)	(0.025)	(0.007)	(0.050)	(0.032)	(0.016)	(0.026)	(0.001)	(0.003)	(0.002)	(0.005)	(0.003)	(0.005)	(0.005)
INUND · DUMMY_4	-0.008	0.038	0.000	-0.034	-0.031	0.013	0.028	-0.001	0.003	-0.003*	0.001	-0.001	0.048***	0.040***
	(0.006)	(0.025)	(0.007)	(0.050)	(0.032)	(0.016)	(0.026)	(0.001)	(0.003)	(0.002)	(0.005)	(0.003)	(0.005)	(0.005)
INUND · DUMMY_5	-0.006	0.012	-0.004	-0.047	-0.025	0.022	0.100***	-0.001	0.003	-0.002	-0.005	-0.002	0.060***	0.024***
	(0.006)	(0.025)	(0.007)	(0.050)	(0.032)	(0.016)	(0.026)	(0.001)	(0.003)	(0.002)	(0.005)	(0.003)	(0.005)	(0.005)
Log of population	-0.285***	-0.229***	-0.431***	-1.382***	1.586***	-0.509***	0.360***	0.532***	-1.679***	0.470***	-0.745*	-0.641**	-6.556***	-5.908***
	(0.014)	(0.061)	(0.018)	(0.123)	(0.078)	(0.040)	(0.066)	(0.130)	(0.244)	(0.154)	(0.452)	(0.251)	(0.496)	(0.440)
Fraction of workers for the manufucture industry	-0.004***	0.003	-0.002**	0.008*	0.002	0.000	0.005**	-0.013**	-0.010	-0.006	-0.022	0.006	0.069***	0.023
	(0.001)	(0.002)	(0.001)	(0.005)	(0.003)	(0.002)	(0.003)	(0.005)	(0.010)	(0.007)	(0.019)	(0.011)	(0.021)	(0.019)
Fraction of workers for the service industry	-0.007***	0.000	0.000	-0.005	0.002	-0.003*	0.005**	-0.001	0.007	0.008	-0.021	-0.019*	-0.065***	-0.064***
	(0.000)	(0.002)	(0.001)	(0.004)	(0.003)	(0.001)	(0.002)	(0.005)	(0.010)	(0.006)	(0.019)	(0.011)	(0.021)	(0.018)
Year 2008	0.087***	0.136***	0.004*	-0.318***	-0.295***	-0.102***	-0.439***	0.086***	0.234***	0.002	-0.333***	-0.253***	0.003	-0.269***
	(0.002)	(0.007)	(0.002)	(0.014)	(0.009)	(0.004)	(0.007)	(0.013)	(0.025)	(0.016)	(0.047)	(0.026)	(0.051)	(0.045)
Year 2009	0.069***	-0.136***	-0.008***	-0.121***	-0.208***	-0.066***	-0.000	0.077***	-0.102***	-0.011	-0.148***	-0.171***	-0.010	0.024
	(0.002)	(0.007)	(0.002)	(0.014)	(0.009)	(0.004)	(0.007)	(0.013)	(0.025)	(0.016)	(0.046)	(0.026)	(0.051)	(0.045)
Year 2011	0.007***	0.027***	0.003	-0.089***	0.048***	0.067***	-0.140***	-0.088***	-0.052	-0.083***	-0.070	0.113***	1.424***	0.471***
	(0.002)	(0.009)	(0.003)	(0.017)	(0.011)	(0.006)	(0.009)	(0.020)	(0.038)	(0.024)	(0.071)	(0.039)	(0.078)	(0.069)
Year 2012	0.049***	0.031***	-0.044***	0.012	0.072***	0.048***	-0.203***	-0.014	0.136***	-0.117***	-0.008	0.119***	0.915***	0.594***
	(0.002)	(0.009)	(0.003)	(0.017)	(0.011)	(0.006)	(0.009)	(0.020)	(0.038)	(0.024)	(0.071)	(0.039)	(0.078)	(0.069)
Year 2013	0.053***	0.002	-0.037***	0.065***	0.075***	0.024***	-0.039***	0.049**	0.046	-0.100***	-0.020	0.102**	0.810***	0.543***
	(0.002)	(0.009)	(0.003)	(0.017)	(0.011)	(0.006)	(0.009)	(0.020)	(0.038)	(0.024)	(0.071)	(0.040)	(0.078)	(0.069)
Year 2014	0.061***	0.100***	-0.021***	0.065***	0.067***	0.014**	-0.029***	0.095***	0.176***	-0.069***	0.054	0.057	0.816***	0.527***
	(0.002)	(0.009)	(0.003)	(0.018)	(0.011)	(0.006)	(0.009)	(0.021)	(0.039)	(0.024)	(0.072)	(0.040)	(0.079)	(0.070)
Year 2015	0.075***	0.064***	-0.025***	0.052***	0.108***	0.008	0.012	0.141***	0.129***	-0.062**	0.066	0.081**	0.744***	0.422***
	(0.002)	(0.009)	(0.003)	(0.018)	(0.011)	(0.006)	(0.009)	(0.021)	(0.039)	(0.025)	(0.073)	(0.040)	(0.080)	(0.071)
Observations	12514	12514	12514	12514	12514	12514	12514	1488	1488	1488	1488	1488	1488	1488
Number of municipalities	1618	1618	1618	1618	1618	1618	1618	187	187	187	187	187	187	187
R2	0.301	0.031	-0.013	-0.006	0.143	0.070	0.270	0.160	0.188	-0.007	-0.059	0.083	0.582	0.490

Note: Robust standard errors are in parentheses. *, **, and *** denote significance at 10%, 5%, and 1% levels, respectively.

Table 3. Regressions of expenditure items for municipalities over the period 2008–2015.

	Non Affected Municipalities								Affected Municipalities							
Dependent Var (in log form)	Personnel expense	Material expense	Mainte-nance expense	Public assis-tance expense	Subsidy expense	Ordinary const-ruction expense	Expenses for recovery from disaster	Accumula ted fund	Personnel expense	Material expense	Mainte-nance expense	Public assis-tance expense	Subsidy expense	Ordinary const-ruction expense	Expenses for recovery from disaster	Accumu-lated fund
INUND · DUMMY_1	0.005	0.009	0.041	0.012	0.009	0.033	0.159*	0.012	0.000	0.000	-0.004	0.014***	0.021***	-0.003	-0.015	0.003*
	(0.007)	(0.010)	(0.030)	(0.009)	(0.022)	(0.038)	(0.092)	(0.014)	(0.000)	(0.003)	(0.003)	(0.002)	(0.002)	(0.005)	(0.009)	(0.002)
INUND · DUMMY_2	0.007	0.036***	0.012	0.004	-0.009	-0.023	-0.065	0.009	0.000	-0.012***	-0.004	-0.009***	0.030***	0.022***	-0.006	0.005***
	(0.007)	(0.010)	(0.030)	(0.009)	(0.022)	(0.038)	(0.092)	(0.014)	(0.000)	(0.003)	(0.003)	(0.002)	(0.002)	(0.005)	(0.009)	(0.002)
INUND · DUMMY_3	0.008	0.031***	0.005	0.009	-0.018	0.064*	0.091	0.016	0.001	-0.003	-0.005*	-0.002	0.038***	0.033***	0.014	0.012***
	(0.007)	(0.010)	(0.030)	(0.009)	(0.022)	(0.038)	(0.092)	(0.014)	(0.000)	(0.003)	(0.003)	(0.002)	(0.002)	(0.005)	(0.009)	(0.002)
INUND · DUMMY_4	0.013*	0.022**	-0.066**	0.011	-0.014	0.014	0.116	0.016	0.001**	-0.007***	-0.005*	-0.002	0.012***	0.036***	0.024***	0.011***
	(0.007)	(0.010)	(0.030)	(0.009)	(0.022)	(0.038)	(0.092)	(0.014)	(0.000)	(0.003)	(0.003)	(0.002)	(0.002)	(0.005)	(0.009)	(0.002)
INUND · DUMMY_5	0.013**	0.030***	-0.073**	0.008	0.051**	0.056	-0.086	0.024*	0.001***	-0.002	-0.001	-0.001	0.012***	0.030***	0.029***	0.012***
	(0.007)	(0.010)	(0.030)	(0.009)	(0.022)	(0.038)	(0.092)	(0.014)	(0.000)	(0.003)	(0.003)	(0.002)	(0.002)	(0.005)	(0.009)	(0.002)
Log of population	-0.535***	-0.676***	-1.436***	-0.139***	-0.974***	-0.810***	-1.483***	-0.435***	-0.929***	-2.233***	-0.387	-0.127	-1.991***	-1.927***	-4.410***	-0.641***
	(0.017)	(0.026)	(0.077)	(0.024)	(0.057)	(0.097)	(0.236)	(0.036)	(0.049)	(0.258)	(0.274)	(0.192)	(0.230)	(0.495)	(0.919)	(0.162)
Proportion of workers in the manufacturing industry	-0.008***	-0.006***	-0.010***	-0.003***	-0.015***	-0.004	-0.044***	-0.002	-0.006***	-0.016	-0.034***	-0.017**	-0.006	0.004	-0.037	0.017***
	(0.001)	(0.001)	(0.003)	(0.001)	(0.002)	(0.004)	(0.009)	(0.001)	(0.002)	(0.010)	(0.011)	(0.007)	(0.009)	(0.019)	(0.036)	(0.006)
Proportion of workers in the service industry	-0.007***	-0.006***	-0.011***	-0.001*	-0.015***	-0.016***	-0.024***	0.001	-0.007***	-0.014	0.010	0.009	-0.003	-0.051***	-0.089**	-0.016***
	(0.001)	(0.001)	(0.003)	(0.001)	(0.002)	(0.003)	(0.008)	(0.001)	(0.002)	(0.010)	(0.011)	(0.007)	(0.009)	(0.019)	(0.036)	(0.006)
Ratio of ordinary LAT to revenue	-0.002***	-0.007***	-0.009***	-0.001**	-0.015***	-0.070***	-0.022***	-0.002***	-0.002***	-0.010***	-0.011***	-0.001	-0.016***	-0.063***	-0.056***	-0.006***
	(0.000)	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)	(0.003)	(0.000)	(0.000)	(0.002)	(0.002)	(0.001)	(0.002)	(0.003)	(0.006)	(0.001)
Ratio of specific grant to revenue	-0.002***	-0.003***	-0.009***	0.001***	-0.009***	0.023***	0.016***	-0.001**	0.000	0.030***	-0.001	0.003***	0.000	-0.011***	0.020***	-0.002***
	(0.000)	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)	(0.003)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.004)	(0.001)
Log of accumulated debt	0.010***	0.009***	-0.007	0.002	0.014***	0.066***	0.014	-0.006**	0.008**	-0.056***	0.032*	-0.006	-0.013	0.049	0.001	-0.006
	(0.001)	(0.002)	(0.006)	(0.002)	(0.004)	(0.007)	(0.017)	(0.003)	(0.003)	(0.017)	(0.018)	(0.012)	(0.015)	(0.032)	(0.060)	(0.011)
Year 2008	0.015***	-0.119***	-0.149***	-0.320***	-0.036***	-0.167***	-0.018	-0.055***	0.035***	0.017	-0.137***	-0.359***	0.035	-0.335***	0.186**	-0.078***
	(0.002)	(0.003)	(0.009)	(0.003)	(0.007)	(0.012)	(0.029)	(0.004)	(0.005)	(0.025)	(0.026)	(0.019)	(0.022)	(0.048)	(0.089)	(0.016)
Year 2009	0.012***	-0.030***	-0.046***	-0.266***	0.273***	-0.114***	-0.143***	-0.022***	0.015***	-0.037	-0.049*	-0.313***	0.262***	-0.105**	-0.234***	-0.054***
	(0.002)	(0.003)	(0.008)	(0.003)	(0.006)	(0.010)	(0.026)	(0.004)	(0.005)	(0.025)	(0.026)	(0.018)	(0.022)	(0.047)	(0.087)	(0.015)
Year 2011	0.015***	0.069***	0.049***	0.062***	0.034***	-0.034**	0.342***	0.015***	0.015**	0.094**	-0.122***	0.107***	-0.034	-0.269***	2.279***	0.157***
	(0.002)	(0.004)	(0.011)	(0.003)	(0.008)	(0.013)	(0.032)	(0.005)	(0.007)	(0.038)	(0.040)	(0.028)	(0.034)	(0.072)	(0.134)	(0.024)
Year 2012	-0.008***	0.045***	0.073***	0.080***	0.057***	0.048***	0.401***	0.032***	-0.014**	0.104***	-0.084**	0.147***	-0.030	-0.157**	2.083***	0.113***
	(0.002)	(0.004)	(0.011)	(0.003)	(0.008)	(0.013)	(0.033)	(0.005)	(0.007)	(0.038)	(0.040)	(0.028)	(0.034)	(0.073)	(0.136)	(0.024)
Year 2013	-0.030***	0.071***	0.084***	0.100***	0.101***	0.100***	0.236***	0.043***	-0.038***	0.202***	0.051	0.028	-0.035	0.099	1.579***	0.113***
	(0.002)	(0.003)	(0.010)	(0.003)	(0.008)	(0.013)	(0.032)	(0.005)	(0.007)	(0.038)	(0.040)	(0.028)	(0.034)	(0.073)	(0.136)	(0.024)
Year 2014	-0.021***	0.123***	0.115***	0.183***	0.104***	0.063***	0.229***	0.071***	-0.031***	0.192***	0.045	0.112***	0.021	0.195***	1.003***	0.131***
	(0.002)	(0.004)	(0.011)	(0.003)	(0.008)	(0.013)	(0.032)	(0.005)	(0.007)	(0.039)	(0.041)	(0.029)	(0.034)	(0.074)	(0.137)	(0.024)
Year 2015	-0.018***	0.176***	0.112***	0.205***	0.183***	-0.002	0.082**	0.111***	-0.030***	0.239***	0.015	0.134***	0.092***	0.216***	0.801***	0.189***
	(0.002)	(0.004)	(0.011)	(0.003)	(0.008)	(0.014)	(0.033)	(0.005)	(0.007)	(0.039)	(0.041)	(0.029)	(0.035)	(0.074)	(0.138)	(0.024)
Observations	12514	12514	12514	12514	12514	12514	12514	12514	1488	1488	1488	1488	1488	1488	1488	1488
Number of municipalities	1618	1618	1618	1618	1618	1618	1618	1618	187	187	187	187	187	187	187	187
R2	0.123	0.582	0.067	0.867	0.222	0.377	-0.057	0.133	0.306	0.716	0.104	0.620	0.441	0.462	0.622	0.294

Note: Robust standard errors are in parentheses. *, **, and *** denote significance at 10%, 5%, and 1% levels, respectively.

ing on material expense" are positive in the non-affected municipalities from the second through the fifth year but negative in the affected municipalities in the second and fourth years. This could be because the affected municipalities reallocated their budgets to cope with the funds required for disaster recovery. Further, expenses on disaster recovery and accumulated debts went up much more in the affected areas than in the non-affected ones. As shown in **Table 3**, outlays, such as personnel expenses and ordinary construction expenses that were required to recover from the disaster and reconstruct the devastated infrastructure and buildings, as well as the accumulated fund, rose after the disaster, while outlays not needed for reconstruction, such as maintenance costs, decreased.

Table 4 presents the results of revenue and expenditure function regressions for prefectures. It shows that the revenue amounts of local taxes and ordinary LAT remained unchanged in the affected and inundation areas, even after the disaster, but those of specific LAT and specific-purpose grants significantly increased from 2011 onward. As seen in the coefficients of the year dummy, revenue from debts and specific-purpose grants, except for specific-purpose grants in 2013, decreased consistently after the disaster, suggesting that the fiscal revenue across the country was lower than what it was before the disaster. **Table 4** also shows that expenses on disaster recovery and accumulated funds seem to have increased in the devastated areas after the disaster. As for the year dummies, spending on personnel expense and ordinary construction mainly decreased in the post-disaster period, and since 2011, spending on disaster recovery increased every year.

5.2. Calculation Results

We calculate the effects of the Nankai earthquake on local revenues and expenditures using the coefficients estimated from the panel data regressions for municipalities and prefectures. As the fiscal effects of the Nankai earthquake are calculated using the estimates from the regressions for the Great East Japan Earthquake, the simulation results here are anticipated from the impacts of the said earthquake and not unique to the Nankai earthquake.

The first section of **Table 5** displays the total amounts of local revenue and expenditure, including both municipalities and prefectures, after the Nankai earthquake. Over the five-year period, excess expenditures amount to JPY -9.0 trillion, meaning that the overall budgetary balance is positive for local governments in the five years after the earthquake.

The rationale for this counterintuitive result is that the affected local governments are not able to spend their allocated budgets due to a lack of contractors who could undertake such large reconstruction and recovery projects like in the 2011 disaster, the delay of recovery projects resulting from difficulties in land expropriation, and the failure of bids for recovery projects caused by increases in input and labor costs. Therefore, a large amount of expenditure is carried forward to subsequent years. In addition, as in **Table 5**, local taxes would have increased every year after the disaster, resulting from a nationwide economic boom by way of reconstruction and rehabilitation, whereas fiscal transfers would not have decreased significantly.

Estimates of the fiscal impacts on affected and non-affected regions (municipalities and prefectures) are provided in the second and third sections of **Table 5**, respectively. As shown in the first row, total revenues decrease in the non-affected areas but increase to a large extent in the affected ones. By contrast, expenditures relevant to the earthquake in the first year of the disaster rise in the non-affected areas but fall in the affected areas. However, beginning in the second year after the disaster, expenditures increase each year in both areas. Combining revenues and expenditures, excess expenditures are apparently positive in the non-affected areas but negative in the affected ones. The results demonstrate that it is not the affected but the non-affected governments that will suffer from fiscal deficits after the Nankai earthquake in the five years after the disaster. By contrast, the affected areas will enjoy fiscal surpluses after the disaster. Although at first glance this is counterintuitive, it is a highly plausible result if one realizes that the national government shifts its financial emphasis to the affected areas, reducing grants to non-affected areas. This is exactly what happened during the recovery process after the Great East Japan Earthquake.

The results show that intergovernmental fiscal transfers to the affected areas increase to a large extent after the earthquake, amounting to JPY 30 trillion in total. The non-affected areas experience a large reduction in transfers shortly after the disaster. These figures show that, in part due to changes in intergovernmental transfers after the disaster, the fiscal impacts of the disaster on local public finances on the non-affected and affected areas are contradictory.

Next, we investigate the effects of the Nankai earthquake on the revenues and expenditures of each municipality and prefecture in the five years following the disaster, mapping the increments. As shown in **Fig. 1(a)**, the affected municipalities, specifically those located around the western Pacific coastal region, experience large increases in revenue. Conversely, municipalities in non-affected areas, specifically those in the Hokkaido, Northeast, Japan Sea, and Kanto areas, face reductions in revenue. As seen in **Fig. 1(b)**, we can confirm the same tendency for prefectures, that is, the affected prefectures face large increases in revenue, while the non-affected ones witness a fall in revenues.

Turning to expenditures, **Fig. 2(a)** shows an interesting tendency in the change in expenditure in municipalities in and around the affected area. Expenditures of the affected municipalities near the western Pacific coastal region show large percentage increases, but some of the inland municipalities in the Pacific coastal region show large decreases in expenditures. One reason for this decrease is that they do not suffer from the tsunami disaster and thus, do not have to spend a lot to recover from it. Generally, throughout the country, many municipali-

Table 4. Regressions of revenue and expenditure Items for prefectures over the period 2008–2015.

	Revenues					Expenditures							
Dependent Var (in log form)	Local tax	Debt	Ordinary LAT	Specific LAT	Specific-purpuse grant	Personnel expense	Material expense	Maintenance expense	Public assistance expense	Subsidy expense	Ordinary construction expense	Expenses for recovery from disaster	Accumulated fund
AFFECTED · DUMMY_1	-0.036	0.331**	0.061	5.248***	2.649***	0.021	0.045	-0.015	0.035	-0.251	-0.306**	2.880***	0.615
	(0.035)	(0.157)	(0.205)	(0.224)	(0.148)	(0.034)	(0.141)	(0.238)	(0.125)	(0.161)	(0.154)	(0.973)	(0.455)
AFFECTED · DUMMY_2	0.039	-0.135	0.037	4.334***	1.733***	0.021	-0.058	-0.143	-0.180*	0.209	-0.362***	3.727***	0.860**
	(0.036)	(0.158)	(0.206)	(0.225)	(0.149)	(0.027)	(0.111)	(0.189)	(0.099)	(0.128)	(0.122)	(0.770)	(0.361)
AFFECTED · DUMMY_3	0.044	0.120	-0.041	3.730***	1.435***	0.050*	-0.242**	0.067	-0.161*	0.328***	-0.189	3.911***	0.688*
	(0.036)	(0.159)	(0.207)	(0.226)	(0.149)	(0.027)	(0.109)	(0.184)	(0.097)	(0.125)	(0.119)	(0.752)	(0.352)
AFFECTED · DUMMY_4	0.057	-0.004	-0.068	4.216***	1.733***	0.037	-0.113	0.062	-0.249**	0.378***	0.008	2.620***	0.845**
	(0.036)	(0.159)	(0.207)	(0.226)	(0.149)	(0.027)	(0.112)	(0.190)	(0.100)	(0.128)	(0.123)	(0.774)	(0.362)
AFFECTED · DUMMY_5	0.047	0.119	-0.106	4.673***	1.759***	0.050*	-0.071	0.100	-0.235**	0.378***	0.274**	3.797***	0.599
	(0.036)	(0.159)	(0.208)	(0.227)	(0.150)	(0.028)	(0.113)	(0.191)	(0.100)	(0.129)	(0.123)	(0.780)	(0.365)
INUND · DUMMY_1	-0.007	0.042	-0.009	0.372***	0.198***	-0.001	0.167***	-0.102***	-0.042**	0.105***	0.095***	0.175	0.109*
	(0.007)	(0.032)	(0.041)	(0.045)	(0.030)	(0.005)	(0.020)	(0.034)	(0.018)	(0.023)	(0.022)	(0.137)	(0.064)
INUND · DUMMY_2	0.011	0.069**	-0.017	0.427***	0.211***	0.004	0.357***	-0.016	-0.021	0.128***	0.001	0.155	-0.025
	(0.007)	(0.032)	(0.041)	(0.045)	(0.030)	(0.005)	(0.020)	(0.034)	(0.018)	(0.023)	(0.022)	(0.137)	(0.064)
INUND · DUMMY_3	0.012	-0.011	-0.034	0.342***	0.134***	-0.005	0.420***	-0.034	-0.011	0.076***	0.024	0.262*	-0.027
	(0.007)	(0.032)	(0.042)	(0.045)	(0.030)	(0.005)	(0.020)	(0.033)	(0.017)	(0.022)	(0.021)	(0.136)	(0.063)
INUND · DUMMY_4	0.013*	-0.070**	-0.046	0.268***	0.112***	-0.003	0.126***	-0.042	-0.011	0.019	0.075***	0.328**	-0.050
	(0.007)	(0.032)	(0.042)	(0.045)	(0.030)	(0.005)	(0.020)	(0.033)	(0.017)	(0.023)	(0.021)	(0.136)	(0.063)
INUND · DUMMY_5	0.011	-0.053	-0.052	0.224***	0.106***	-0.004	0.030	0.018	-0.016	-0.026	0.092***	0.266*	-0.026
	(0.007)	(0.032)	(0.042)	(0.046)	(0.030)	(0.005)	(0.020)	(0.033)	(0.017)	(0.023)	(0.021)	(0.136)	(0.064)
Log of population	-0.930***	-1.490**	2.758***	-0.340	-1.351**	-0.695***	-2.118***	-3.096***	0.914**	-1.785***	-1.392***	-5.524**	-0.491
	(0.146)	(0.649)	(0.846)	(0.923)	(0.609)	(0.097)	(0.396)	(0.671)	(0.353)	(0.455)	(0.434)	(2.740)	(1.282)
Proportion of workers in the manufacturing industry	0.004	-0.043*	-0.058**	-0.000	0.008	0.001	0.002	-0.018	0.014	-0.003	-0.012	-0.007	-0.006
	(0.005)	(0.022)	(0.029)	(0.032)	(0.021)	(0.003)	(0.014)	(0.023)	(0.012)	(0.016)	(0.015)	(0.094)	(0.044)
Proportion of workers in the service industry	0.000	0.002	0.024*	0.016	-0.018**	0.002	0.001	0.001	0.014***	-0.006	0.006	0.012	0.040**
	(0.002)	(0.010)	(0.013)	(0.014)	(0.009)	(0.001)	(0.006)	(0.010)	(0.005)	(0.007)	(0.007)	(0.041)	(0.019)
Ratio of ordinary LAT to revenue						-0.000	-0.009***	-0.005	0.002	-0.016***	-0.018***	0.007	-0.011
						(0.001)	(0.003)	(0.004)	(0.002)	(0.003)	(0.003)	(0.018)	(0.008)
Ratio of specific grant to revenue						0.001	0.021***	0.009**	0.010***	0.011***	0.014***	0.032*	0.008
						(0.001)	(0.003)	(0.005)	(0.002)	(0.003)	(0.003)	(0.019)	(0.009)
Year 2008	0.200***	-0.174***	-0.038	-0.096	-0.097**	0.039***	-0.109***	-0.033	-0.208***	-0.122***	0.056	0.274	-0.021
	(0.011)	(0.051)	(0.067)	(0.073)	(0.048)	(0.008)	(0.031)	(0.053)	(0.028)	(0.036)	(0.034)	(0.215)	(0.101)
Year 2009	0.034***	0.070	0.026	-0.074	0.301***	0.004	-0.161***	-0.019	-0.213***	-0.137***	0.022	-0.110	-0.029
	(0.011)	(0.051)	(0.066)	(0.072)	(0.048)	(0.008)	(0.033)	(0.056)	(0.029)	(0.038)	(0.036)	(0.229)	(0.107)
Year 2011	-0.011**	-0.165***	0.028	0.367***	-0.090***	-0.001	0.037***	0.019	0.048***	0.020	-0.031**	0.405***	-0.048
	(0.005)	(0.022)	(0.029)	(0.032)	(0.021)	(0.003)	(0.014)	(0.024)	(0.012)	(0.016)	(0.015)	(0.096)	(0.045)
Year 2012	0.005	-0.112***	0.007	0.097***	-0.132***	-0.016***	-0.016	0.024	-0.028**	0.050***	-0.034**	0.673***	-0.020
	(0.005)	(0.022)	(0.029)	(0.032)	(0.021)	(0.003)	(0.014)	(0.024)	(0.013)	(0.016)	(0.016)	(0.098)	(0.046)
Year 2013	0.033***	-0.159***	-0.017	0.079**	0.042**	-0.058***	-0.069***	0.017	-0.052***	0.028*	0.024	0.367***	-0.072
	(0.005)	(0.022)	(0.029)	(0.031)	(0.021)	(0.003)	(0.014)	(0.023)	(0.012)	(0.016)	(0.015)	(0.096)	(0.045)
Year 2014	0.089***	-0.253***	0.014	0.045	-0.139***	-0.033***	-0.000	0.070***	0.003	0.088***	0.040***	0.539***	-0.073
	(0.005)	(0.022)	(0.029)	(0.031)	(0.021)	(0.003)	(0.014)	(0.024)	(0.012)	(0.016)	(0.015)	(0.097)	(0.045)
Year 2015	0.236***	-0.338***	0.026	0.046	-0.163***	-0.030***	0.032**	0.048*	0.035***	0.213***	-0.051***	0.365***	-0.136***
	(0.005)	(0.022)	(0.029)	(0.032)	(0.021)	(0.004)	(0.014)	(0.024)	(0.013)	(0.016)	(0.016)	(0.099)	(0.046)
Observations	376	376	376	376	376	376	376	376	376	376	376	376	376
Number of prefecturs	47	47	47	47	47	47	47	47	47	47	47	47	47
R2	0.940	0.527	0.051	0.898	0.812	0.759	0.845	0.162	0.629	0.774	0.623	0.472	0.060

Note: Robust standard errors are in parentheses. *, **, and *** denote significance at 10%, 5%, and 1% levels, respectively.

Table 5. Total amounts of local government revenue and expenditure after the Nankai earthquake.

Years after the disaster	First year	Second year	Third year	Fourth year	Fifth year	Total
Total						
Increment in revenue	5,581,218,426	4,661,556,181	5,564,300,724	4,970,295,377	6,900,788,813	27,678,159,521
Increment in expenditure	660,332,926	1,343,252,656	2,582,138,138	5,705,376,097	8,376,388,970	18,667,488,786
Excess expenditure	-4,920,885,501	-3,318,303,525	-2,982,162,586	735,080,720	1,475,600,157	-9,010,670,735
Increment in local taxes	-904,402,470	-422,267,467	286,456,841	1,836,014,801	4,294,525,419	5,090,327,124
Increment in intergovernmental fiscal transfers	7,256,187,031	5,763,038,441	6,369,816,129	5,164,635,062	5,125,280,083	29,678,956,746
Non-Affected Areas						
Increment in revenue	-904,498,834	-767,344,480	270,703,363	-23,434,942	522,001,939	-902,572,953
Increment in expenditure	766,094,880	1,177,659,436	1,140,363,254	1,955,622,504	2,368,942,050	7,408,682,123
Excess expenditure	1,670,593,714	1,945,003,916	869,659,891	1,979,057,446	1,846,940,111	8,311,255,077
Increment in local taxes	3,236,147	27,866,598	153,921,212	474,301,210	958,845,566	1,618,170,734
Increment in intergovernmental fiscal transfers	-336,624,084	-561,189,933	322,466,479	-65,068,164	196,756,636	-443,659,066
Affected Areas						
Increment in revenue	6,485,717,260	5,428,900,660	5,293,597,361	4,993,730,319	6,378,786,874	28,580,732,474
Increment in expenditure	-105,761,954	165,593,219	1,441,774,884	3,749,753,593	6,007,446,921	11,258,806,663
Excess expenditure	-6,591,479,214	-5,263,307,441	-3,851,822,477	-1,243,976,726	-371,339,953	-17,321,925,811
Increment in local taxes	-907,638,617	-450,134,066	132,535,629	1,361,713,591	3,335,679,854	3,472,156,391
Increment in intergovernmental fiscal transfers	7,592,811,114	6,324,228,374	6,047,349,649	5,229,703,226	4,928,523,448	30,122,615,811

ties, including those in non-affected areas, increase their expenditures after the disaster. **Fig. 2(b)** presents the corresponding maps for the prefectures. Analogous to the case of municipalities, the affected prefectures, specifically those that experience inundation by the tsunami, increase their spending, but the non-affected prefectures decrease theirs.

Figure 3 maps excess expenditures, reflecting changes in both revenues and expenditures. **Fig. 3(a)** shows that excess expenditures are largely positive for non-affected municipalities, specifically those in the Hokkaido, Northeast, Japan Sea, and Kanto regions, but are negative for the affected areas or those on the Pacific coast. In particular, inland municipalities around the Pacific coast enjoy large amounts of excess revenue. As shown in **Fig. 3(b)**, the non-affected prefectures face positive excess expen-

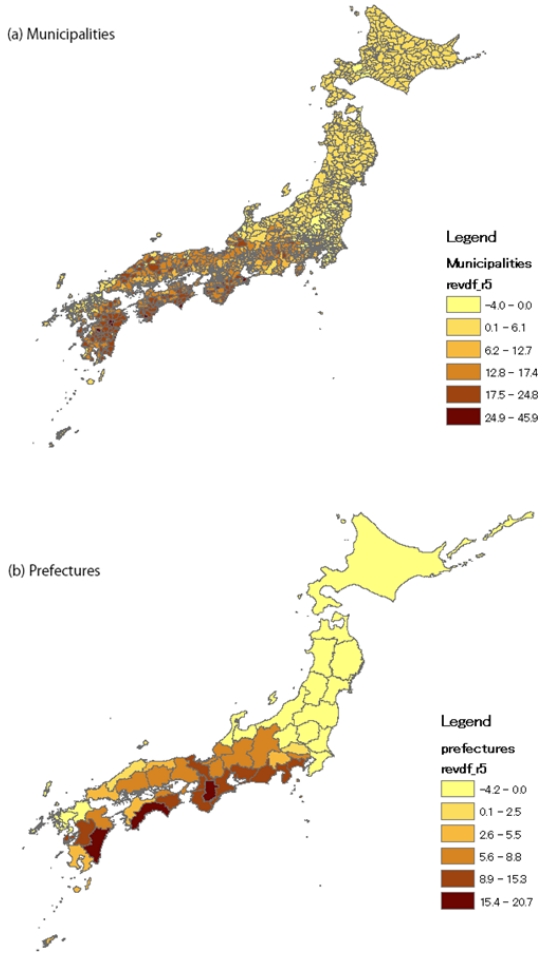

Fig. 1. Revenue increase over five years.

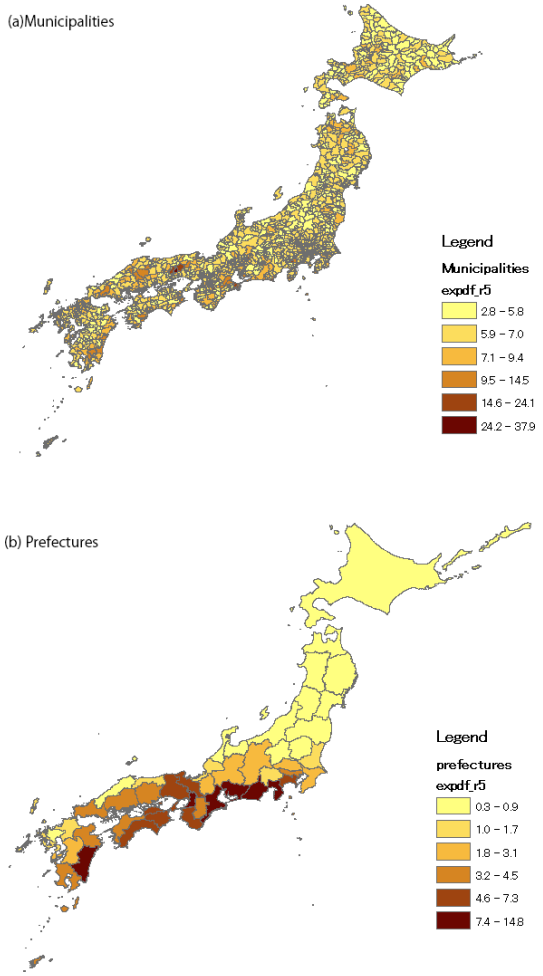

Fig. 2. Expenditure increase over five years.

ditures, whereas many of the affected prefectures witness excess revenue.

Changes in local tax revenues are mapped in **Fig. 4**, which shows that local taxes fall dramatically in most of the affected municipalities, specifically those around the Pacific coastal area, whereas tax revenues rise in non-affected municipalities, particularly in the Hokkaido, North-east, Japan Sea, and Kanto regions. This decrease in the affected areas is due to revenues from property taxes and inhabitant taxes declining, mainly because of partial exemptions. However, at the prefecture level, this tendency in local taxes does not appear, as seen in **Fig. 4(b)**.

Figure 5 maps the changes in intergovernmental fiscal transfers, including both general grants and specific-purpose grants from national and prefecture governments. As seen in **Fig. 5(a)**, throughout the post-disaster period, fiscal transfers increase to a large extent in the affected municipalities, specifically those in the western Pacific coastal area, whereas some of the non-affected municipalities in the Hokkaido, North-east, Japan Sea, and Kanto regions receive less in transfers after the disaster. Similarly, in **Fig. 5(b)**, the affected prefectures tend to increase their grants, but the non-affected ones reduce grants.

5.3. Estimation of the National Fiscal Demand for the Nankai Earthquake

Along with the estimation results of fiscal revenues and expenditures, we attempt to determine the fiscal demand of the national government for disaster recovery. Because we do not have a large enough sample to estimate statistically the fiscal requirements of the national government, we assume that the national–local ratio of expenditures will hold during the reconstruction after the Nankai earthquake. This is a rather strong assumption, but it enables us to estimate the overall fiscal requirement caused by the Nankai earthquake as follows.

In **Table 6**, data for the overall fiscal requirement for the Great East Japan earthquake (A) are from the Reconstruction Agency. The national fiscal requirement (B) is estimated by subtracting the local governments' fiscal requirement from the overall fiscal requirement (A − C). Dividing the national requirements by the local fiscal requirements (B/C) gives the national–local ratio of fiscal demand attributable to the Great East Japan Earthquake for each year (D). As we have already estimated local government fiscal requirements for the Nankai earthquake (G), we multiply this by the national–local ratio (G ∗ D) to derive an estimate of national fiscal requirements (F).

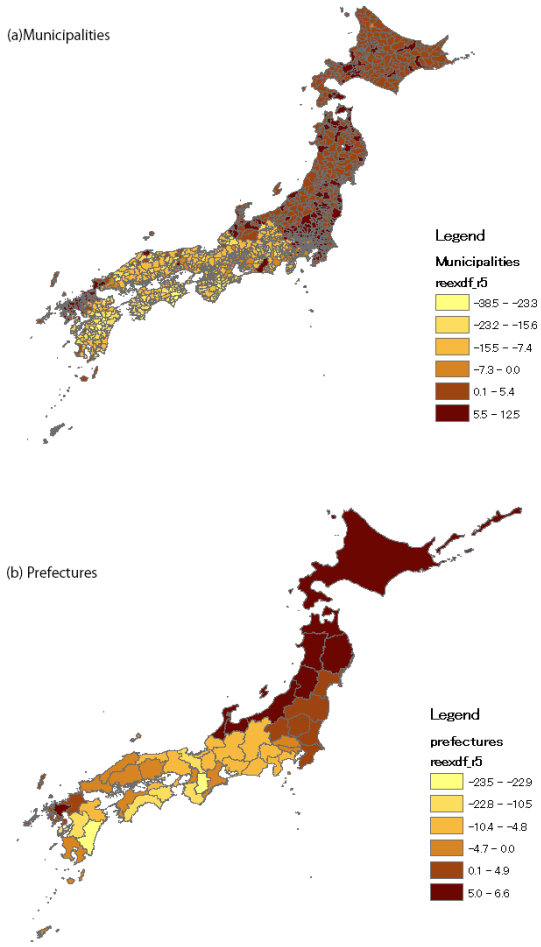

Fig. 3. Excess expenditures over five years.

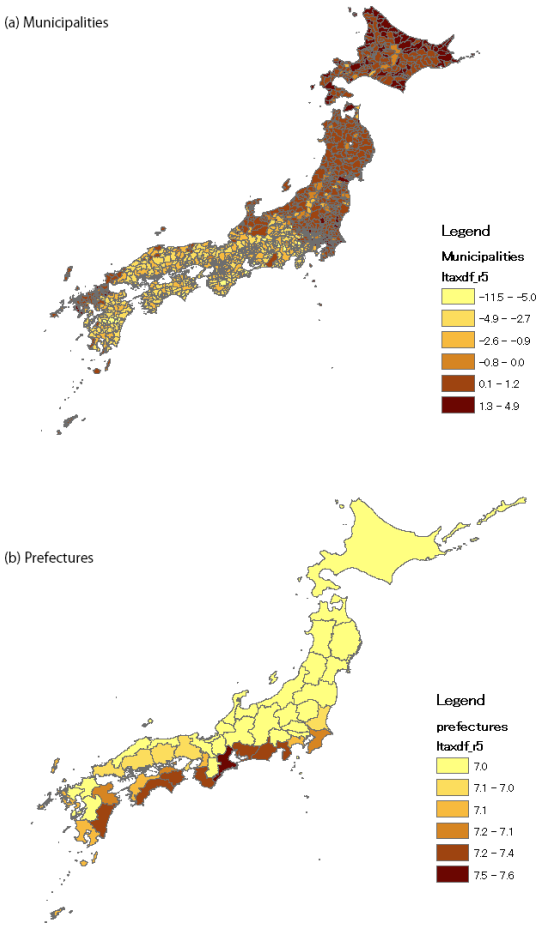

Fig. 4. Local tax revenues over five years.

Adding both requirements (G + F) yields the overall fiscal demand (E). The actual values after the Great East Japan Earthquake amount to as much as JPY 27.5 trillion. For the Nankai earthquake, the total fiscal requirement is about JPY 161 trillion in the five years after the earthquake, and it is specifically largest in the first year, at JPY 80 trillion. The total fiscal requirement over the five years is 5.9 times that of the Great East Japan Earthquake.

6. Conclusion and Policy Implications

To summarize, the increment in revenues associated with the Nankai earthquake is significantly positive in the five years after the disaster, but the increment in expenditures is slightly positive in the same period. Basically, the affected local governments (municipalities and prefectures, specifically those around the Pacific coastal area), witness excess revenues. This is due to an increase in revenues that is larger than the increase in expenditures. Non-affected local governments, mainly in the Hokkaido, North-east, Japan Sea, and Kanto regions, witness large excess expenditures, owing to a very large increase in expenditures, combined with a decrease in revenues.

In total, the estimated fiscal requirements in the two years after the earthquake are about JPY 161 trillion, 5.9 times that of the 2011 Great East Japan Earthquake. However, this could be an underestimation for several reasons. First, as is shown in Eq. (1), the parameter that we estimated was for tsunami inundation, which logically means our model captures only the tsunami's fiscal impact, while the tremors of the anticipated Nankai earthquake are expected to cause more damage on top of those caused by the tsunami. This is a limitation of our analysis. Because of collinearity between damage and inundation, the only damage variable for municipalities adopted here is that of the inundated areas. This variable was chosen because almost all the damage during the Great Eastern Japan Earthquake was caused by the tsunami, with little damage from the tremors.

Second, we could not fully consider the concentration of capital in the disaster area of the Nankai earthquake. The municipalities that would be affected by the earthquake include metropolitan areas, such as Nagoya and Osaka, and the damage would be much greater than the damage in other cities.

Third, we did not consider the rise in financial liability of the Japanese governments after the Great East Japan Earthquake. One of the most relevant changes was the earthquake insurance framework. The burden on the national government was only JPY 540 billion, which is as

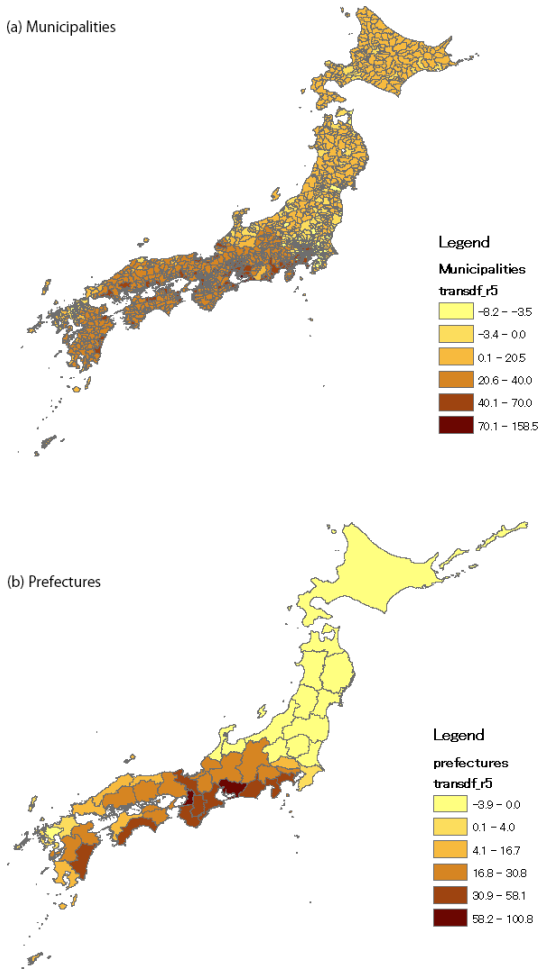

Fig. 5. Intergovernmental fiscal transfers in the five-year post-disaster period.

Table 6. The national government's fiscal requirements in the case of the Nankai earthquake.

Fiscal Needs/Year	First	Second	Third	Fourth	Fifth	Total
The Great East Japan Earthquake						
(A) Overall	13.88	3.45	4.04	3.00	3.13	27.50
(B) National government (A – C)	12.56	2.35	3.00	2.16	2.32	22.39
(C) Local government	1.32	1.10	1.04	0.84	0.81	5.11
(D) National–local ratio (B/C)	9.53	2.14	2.88	2.56	2.85	4.38
The Nankai Earthquake						
(E) Overall (G + F)	79.94	19.86	23.45	18.63	18.99	160.88
(F) National government (G*D)	72.35	13.54	17.40	13.40	14.07	130.75
(G) Local Government	7.59	6.32	6.05	5.23	4.93	30.12

Note: Units are trillion JPY. Data for the overall fiscal needs for the Great East Japan Earthquake (A) are from the Reconstruction Agency. Grants from prefectures to municipalities are not excluded from municipal accounts. For the Great East Japan Earthquake, fiscal needs in the first year after the disaster are calculated from the 2011 regular budget and the 1–3 supplementary budgets. Fiscal needs in the second year are calculated from the 2012 regular and supplementary budgets.

much as 45% of the total insurance payments attributable to the Great East Japan Earthquake. However, the allocation of the financial burden was changed in April 2019, increasing the national government's burden significantly. The national government would have to cover JPY 1.13 trillion under the current arrangement if the damage were as great as that during the Great East Japan Earthquake. In addition, the estimated number of completely collapsed houses attributable to the Nankai earthquake is likely to be 3–5 times the number during the Great East Japan Earthquake. This will increase the national fiscal burden by several trillion yen. However, because this study is based on an empirical model of the 2011 earthquake, we could not construct a coherent model that could explain such an increase in fiscal requirements.

In spite of these limitations, we can conclude that the fiscal requirement of JPY 160 trillion is currently too great to manage, and it will become much more difficult if the current fiscal trend in Japan continues. The finding that the Nankai earthquake will create a huge financial disparity between affected and non-affected municipal governments is robust, and so far, this fact has not been considered in Japanese disaster-management policymaking. The policy implications that can be derived from this study are as follows. The fiscal deficit will be more severe in the non-affected municipalities than in the affected ones. Because the Nankai earthquake will affect a larger number of municipalities, the fiscal burden of the non-affected municipalities would be relatively higher. This indicates that the Nankai earthquake will not be just a local disaster but also a national catastrophe. Alternative sources of revenues should be considered, even for the non-affected municipalities. Finally, the Japanese government must consider other ways of risk financing aside from public bonds. The global financial market did not allow the national government to issue public bonds without collateral to finance the recovery from the Great East Japan Earthquake of 2011. This meant that the Japanese government had to raise income taxes for reconstruction. The results of our analysis imply that the Japanese government will have to face far more severe financial constraints during the Nankai earthquake recovery process.

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