Measuring the indirect losses from natural disasters: the case of the Great East Japan Earthquake[1]

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ABSTRACT

In this paper, we attempt to measure the indirect loss of the Great East Japan Earthquake by monthly real GRP of three prefectures in Japan. First, we estimated the monthly GRP for 47 prefectures. In Japan, the cabinet office of the Government of Japan publishes monthly expenditure statistics for each prefecture called the Regional Domestic Expenditure Index (RDEI). The statistics reveal several components of GRP such as private final consumption, private residential investment, private equipment investment, and public investment. We can estimate monthly GRP by estimating the rest of expenditure component. We estimate the government final consumption and net export for 47 prefectures by panel data estimation.

Then, we measure the indirect loss and reconstruction demand accruing from the Great East Japan Earthquake. We estimated counterfactual monthly GRP (in case of no disaster) for three disaster-stricken prefectures (Iwate, Miyagi, and Fukushima). Counterfactual data is estimated by the GRPs of other prefectures, which are highly correlated with disaster prefectures but not damaged by the earthquake. Then, we measure indirect loss and reconstruction demand related to the earthquake by comparing actual data with counterfactual data.

According to the data, after a small reduction in output, the reconstruction demand gradually emerged. Because of the huge damage to infrastructure and capital stock, the reconstruction demand is large. As of December 2013, the accumulated recovery demand is approximately 2.5 trillion yen (25 billion dollars).

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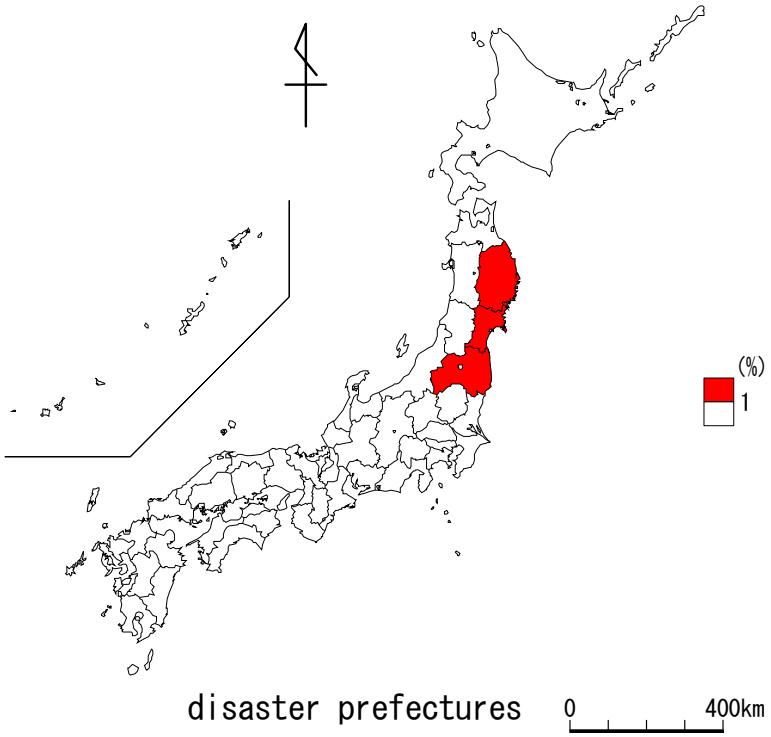
1 Introduction

In Japan, maintaining records of the regional economic condition has assumed great important since the Great East Japan Earthquake occurred. However, official statistics are not able to reveal the current economic status. The figure of national GDP is released 70 days after the concerned period ends. However, the Gross Regional Product (GRP) for 47 prefectures in Japan was released two years and three months after the earthquake period. We only have annual data for 2011 (as of November 2014) for the GRP of 47 prefectures; thus, the economic condition of regions in 2012 and 2013 is not revealed in official statistics. Although the cabinet office compiles the GRP for each prefecture, the time of its release is very late. Thus, we attempted to calculate the monthly GRP for each prefecture to capture the current economic status as promptly as possible.

The GRP can be released at the same time as the national GDP and can be applied to various analysis. In this paper, we introduce an application of the GRP to the Great East Japan Earthquake.

Figure1 illustrates 47 prefectures of Japan and the three disaster prefectures—Iwate, Miyagi, and Fukushima. Fukushima is the location of the nuclear power plant accident.

Figure1 Disaster Prefectures



2. Real Monthly GRP

2.1 Release timing

In Japan, the national GDP is released quarterly approximately 70 days after the concerned period. For example, the data for the second quarter of 2014 is released in November 2014.

However, the GRP of prefectures is released rather late. Each local government of the 47 prefectures calculates the GRP for the respective prefecture. The entire process takes two years and three months. This is mainly because it takes time to compile the companies' production data. In June 2014, the cabinet office made public the GRP of 47 prefectures for the year 2011. It must be noted that the cabinet office is not in charge of compiling statistics but collecting prefecture data.

Some prefectures, including the three earthquake-stricken prefectures, release preliminary data. Thus, we have partial knowledge of the 2012 data, but there are no data pertaining to 2013; therefore, it is difficult to capture the current status of the economy of various prefectures.

2.2 Calculating monthly data

We attempted to estimate monthly GRP from the expenditure side. From the expenditure side, GRP comprises private consumption, private equipment investment, public investment, and so on. The Japanese cabinet office releases most of these components in a monthly index that is called the Regional Domestic Expenditure Index (RDEI). However, the office does not release government consumption and net export. We calculate these two components.

2.3 RDEI

The RDEI is official data for the monthly expenditure index. Here, we briefly explain the methodology of compiling the RDEI. The RDEI began publishing in May 2012. For example, they use various sales data to calculate private consumption. Table1 presents a summary of the RDEI estimation method.

Table1 The RDEI estimation method

item	Method
Private Consumption	Divided by 44 types of consumption, calculated by multiplying the percentage change by the reference point (2009 year average)
Private Residential Investment	Ministry of Land, Infrastructure, Transport, and Tourism's "Statistics of Construction Starts"
Private Fixed Investment	Estimated by Building, Construction, Machinery, Aircraft, Motor Vehicle, and other transportation machinery
Public Investment	Ministry of Land, Infrastructure, Transport, and Tourism's "Statistics of Construction Order by 47 Prefectures"
Real data	Compile real data using deflator
Change to amount base data	RDEI is an index (2005 = 100). We need to change the base amount.

2.4 Government Consumption

We estimate government consumption by panel data estimation. Dependent variable is 47 government consumptions and explanation variables are labor cost of local government, medical expenditure and care expenditure for aged people.

In Japan, there are two main medical insurance systems. The first is for employees (medical1 in the table) and the second is for self-employed business owners (medical2 in

the table).

For the estimation of monthly government consumption, we choose equation (4) because of the high adjusted R squared.

Table 2 Estimation of Government Consumption

variables	(1)	(2)	(3)	(4)
constant	1.361 ***	6.156 ***	1.133 ***	4.875 ***
	(0.085)	(0.273)	(0.088)	(0.295)
government labor cost etc.	0.791 ***	0.238 ***	0.763 ***	0.200 ***
	(0.022)	(0.029)	(0.040)	(0.029)
medical1			0.030	0.125 ***
			(0.034)	(0.013)
medical2			0.093 **	0.180 ***
			(0.043)	(0.018)
medical	0.155 ***	0.050 ***		
	(0.035)	(0.010)		
care	0.138 ***	0.178 ***	0.206 ***	0.111 ***
	(0.041)	(0.013)	(0.043)	(0.014)
fixed effect	no	yes	no	yes
R^2	0.983261	0.999565	0.982696	0.999650
number of observations	423	423	423	423

note:*** is significant at the 1% level,**is significant at the 5% level.

2.5 Estimation of Net Export

Many prefectures release only net export (export – import). Since export and import data cannot be known separately, we choose the net export of 47 prefectures as dependent variables. The explanation variables are regional demand (CP? + IOP? + IHP? + IPUB?), national demand (IIP), and foreign currency exchange rate (Yen/Dollar, FREXDA).

Regional demand is the sum of the RDEI, CP is consumption, IOP is private equipment investment, IHP is private residential investment, and IPUB is public investment; "?" indicates panel data.

When the yen depreciates compared to the dollar, net export is expected to increase. Thus, the parameter FREXDA is expected to be positive. However, equation (2) shows that the FREXDA parameter is negative. Thus, we omitted FREXDA and used equation (3).

Table 3 Estimation of real net export

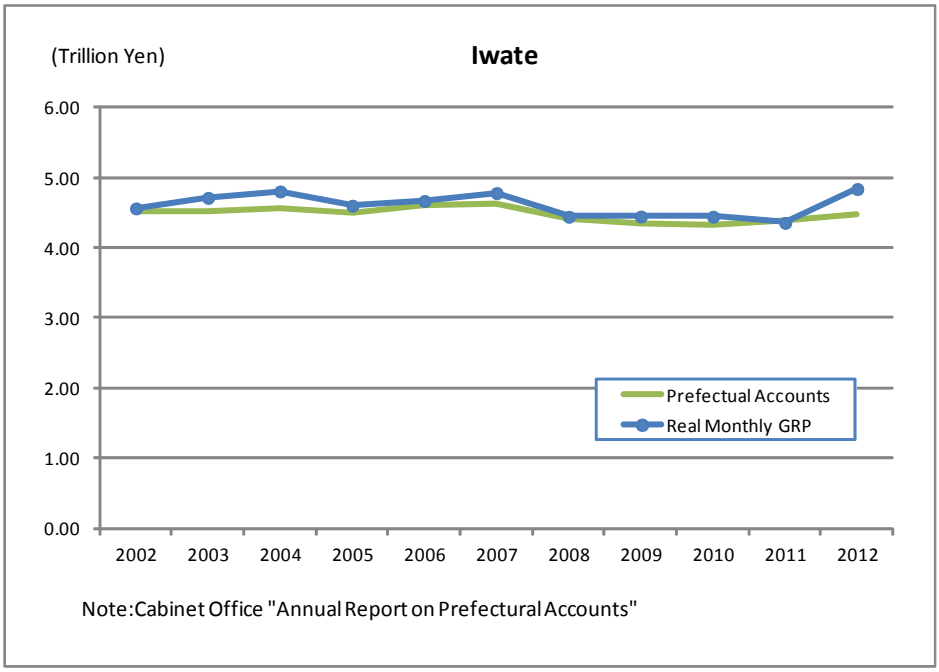
variables	(1)	(2)	(3)
C	−8814005	−7201767 ***	−7660745 ***
	(15953921)	(1198025)	(1202202)
LOG(CP?+IOP?+IHP?+IPUB?)	2889269	−1731358 **	−2378045 ***
	(285406)	(685674)	(660222)
LOG(IIP)	1820599	2873846 ***	2705335 ***
	(3673954)	(312229)	(310891)
LOG(FREXDA)	−852069	−510817 ***	
	(2143021)	(165612)	
fixed effect	no	yes	yes
R^2	0.1915	0.9956	0.9955
number of observations	423	423	423

note:*** is significant at the 1% level,**is significant at the 5% level.

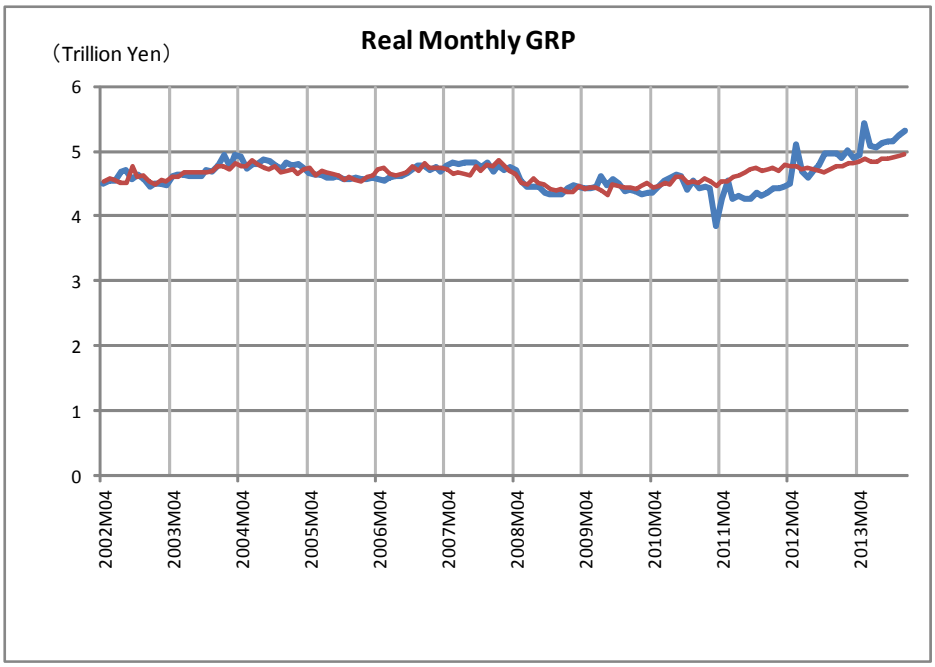
2.6 Estimation of Monthly GRP

We estimate monthly GRP by summing up the RDEI and government consumption and net export. Figure 2-4 illustrates the real monthly GRP of disaster prefectures. The red line is the baseline. The estimation result is presented in the next chapter.

Figure 2 Iwate prefecture

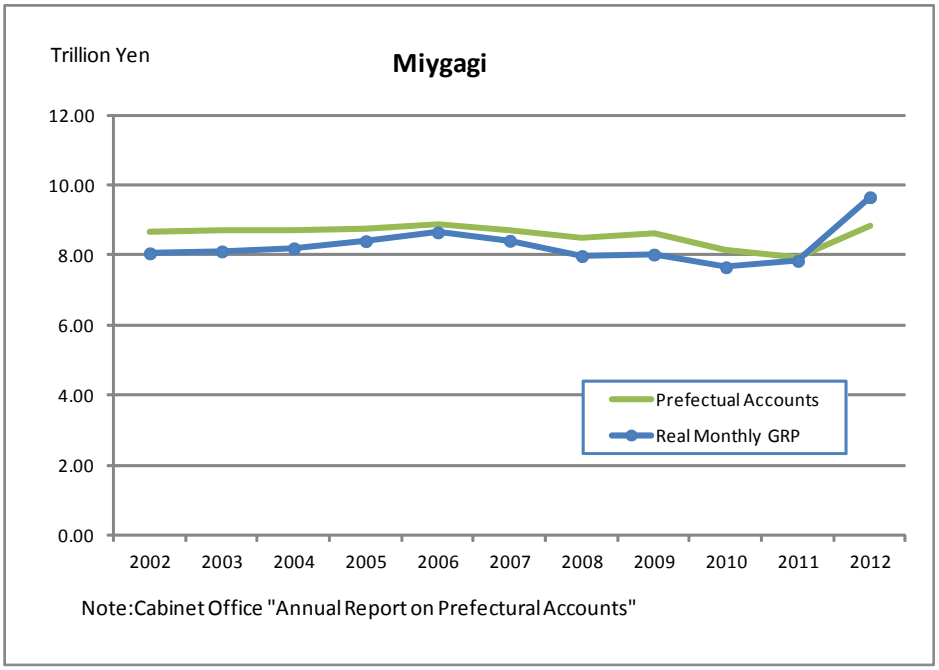


Note:Cabinet Office "Annual Report on Prefectural Accounts"



Note:Thin line indicates a case without the earthquake.

Figure 3 Miyagi prefecture



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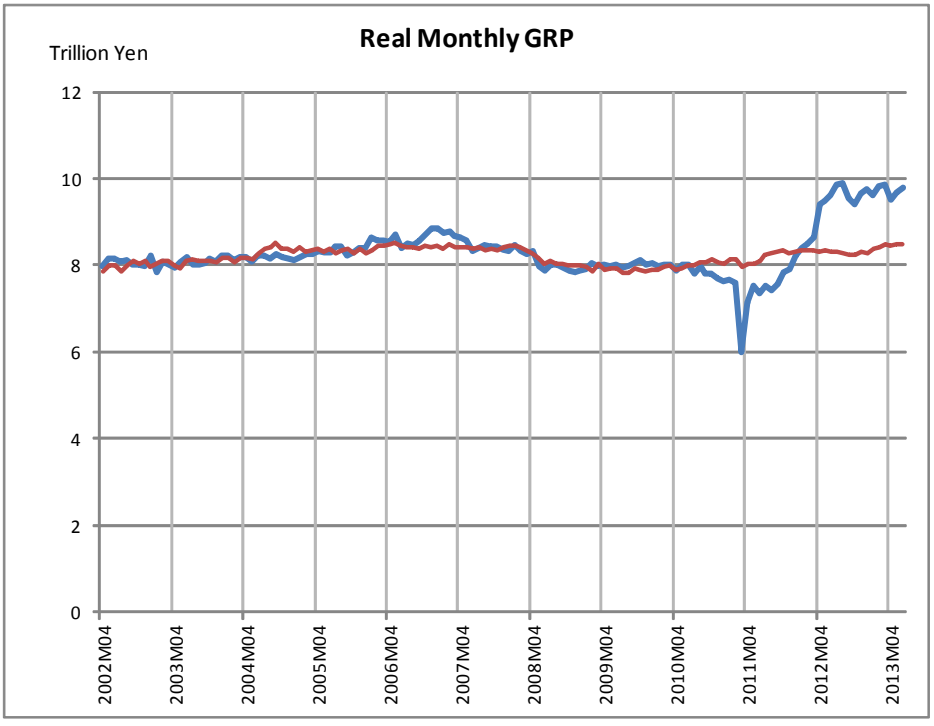
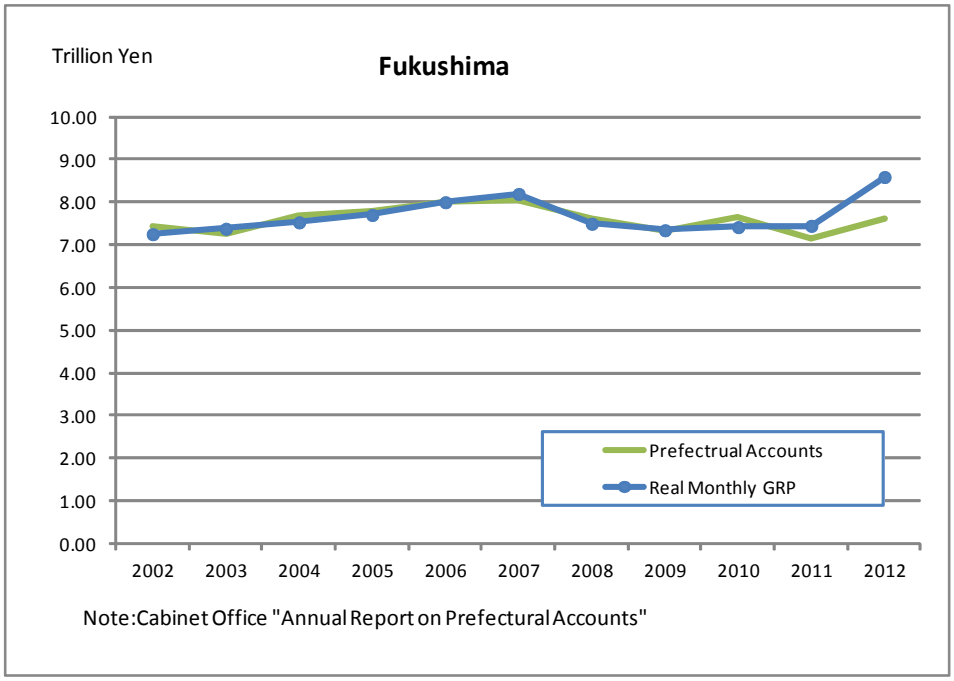


Note:Thin line indicates a case without the earthquake.

Figure 4 Fukushima prefecture



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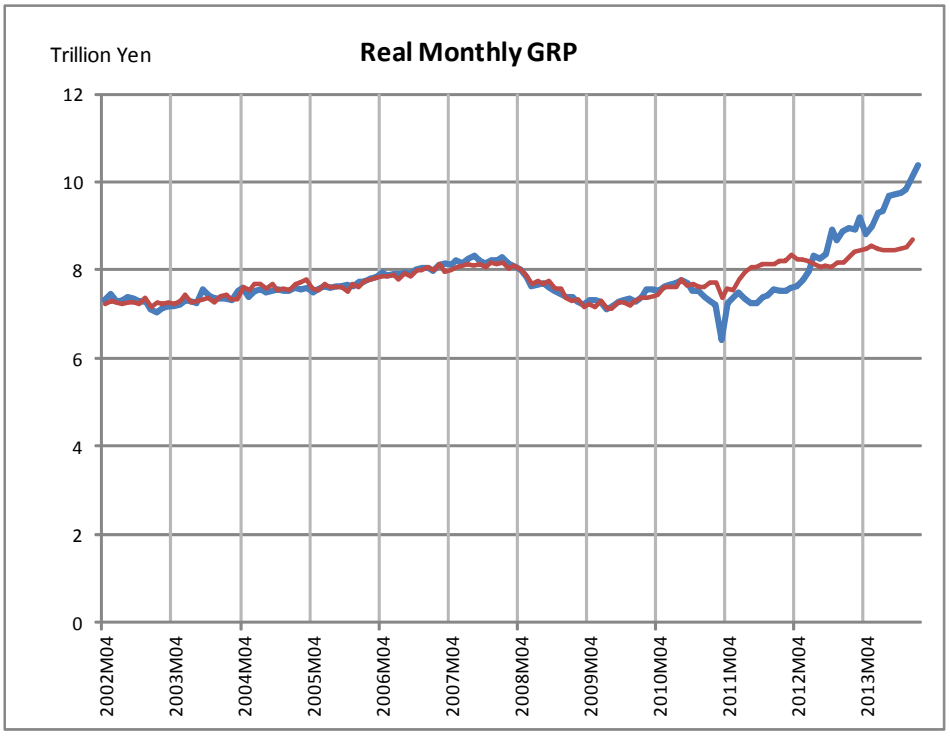


Note:Thin line indicates a case without the earthquake.

3. Application to the Great East Japan Earthquake

3.1 About the Great East Japan Earthquake

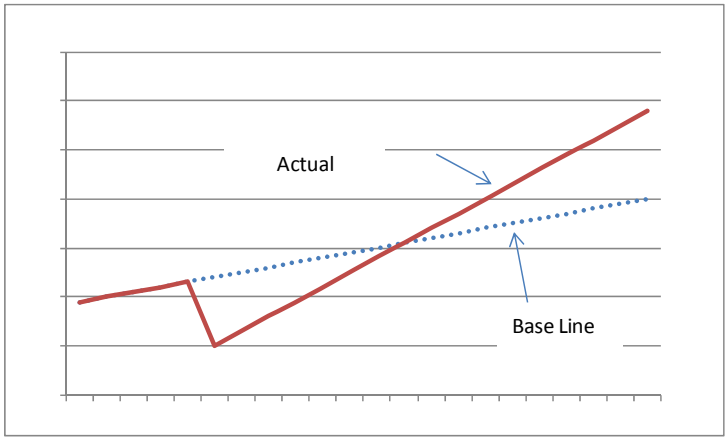
The Great East Japan Earthquake occurred on March 11, 2011 in Miyagi with a magnitude of 9.0 and an intensity of 7. The earthquake claimed 16000 lives, with 3000 people missing. Further, 130,000 residences were completely destroyed, and 240,000 were partially destroyed. The direct loss accruing from the earthquake was 16 trillion and 900 billion yen ($169 billion), as estimated by the Cabinet office on July 24, 2011.

3.2 Economics of Disaster

According to Cavallo and Noy (2009), while the short-run effect of the disaster is negative, the long-run effect of disaster is inconclusive. Some people emphasize the effect of "Creative Deconstruction" given by Schumpeter, but other people emphasize the negative impact of the disaster.

According to the Hallegatte et al. (2010), direct loss includes the damage of physical equipment, while indirect loss is the economic loss if the disaster would not have occurred. Indirect loss is difficult to measure as it is difficult to determine the baseline that is the output in the case of no disaster, and we have to estimate counterfactual data.

Figure5 Output after the disaster



3.3 Counterfactual data

In this study, we followed the method given by Hsiao, Cheng, and Wan (HCW) (2012). Counterfactual data can be estimated using another prefecture's data that was not stricken by the disaster.

Many prefectures were damaged by the earthquake, but there were some prefectures that were less damaged. We attempted to check the influence of the earthquake influence by using the following estimation. “Trend” is the time trend variable.

$$\log(\text{prefecture GRP}) = \alpha + \beta \ \text{Trend}.$$

The estimation period is from March 2009—which is the end of official business cycles—to December 2013. The breaking point is March 2011. The null hypothesis is “β is the same before and after the breaking point.”

The figure indicates that the white portion indicates a rejection of the null hypothesis at the 1% level, light blue indicates the rejection of the null hypothesis at the 5% level, and deep blue indicates rejection of the null hypothesis at the 10% level.

We choose Aomori, Akita, Shizuoka, Wakayama, Ehime, Kumamoto, and Kagoshima as the prefectures that suffered less damage.

The estimation result is shown as the red line in Figures 2, 3, and 4.

Figure 6 p value of the rejection of the null hypothesis

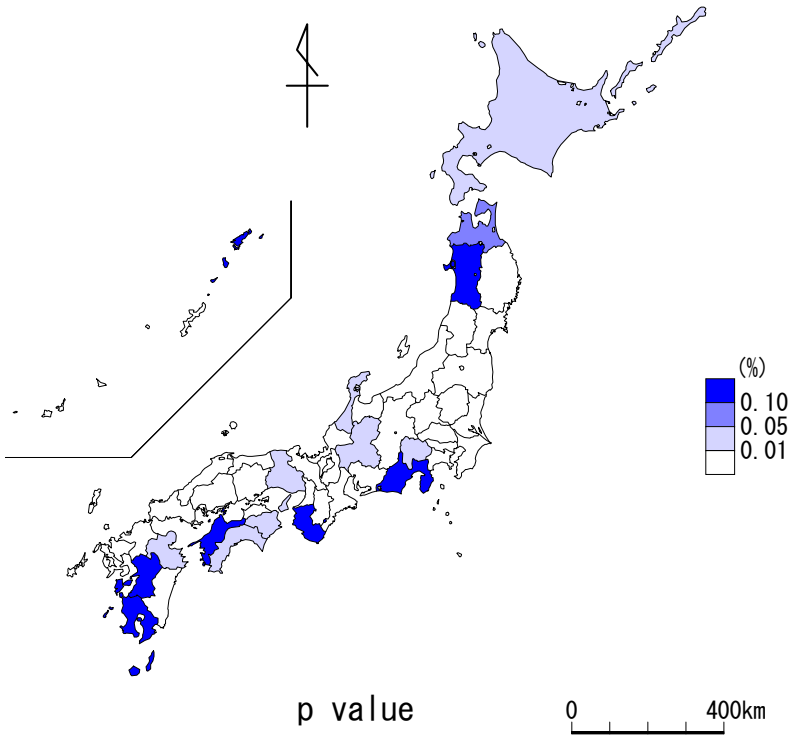


Table 4 OLS regressions based on log GRP

Method: Least Squares
Sample: 2002M04 2011M02
Included observations: 107

	Iwate	Miyagi	Fukushima
Constant	−0.681 ***	0.750 ***	−0.800 ***
Aomori	−0.079 *	−0.164 ***	0.099 **
Akita	−0.046	0.354 ***	0.125 *
Shizuoka	0.693 ***	0.396 ***	0.755 ***
Wakayama	−0.089	−0.016	0.426 ***
Ehime	0.388 ***	0.161 *	−0.005
Kumamoto	−0.180 *	−0.030	0.105
Kagoshima	0.181 **	−0.073	−0.195 ***
R-squared	0.672	0.568	0.854
Adjusted R-squared	0.649	0.537	0.844

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

3.4 Reconstruction Demand

For 2011, the counterfactual data is given below the actual data. After the middle of 2012, the actual data is beyond the counterfactual data, and the demand exceeds indirect loss.

Figure 7 Reconstruction demand

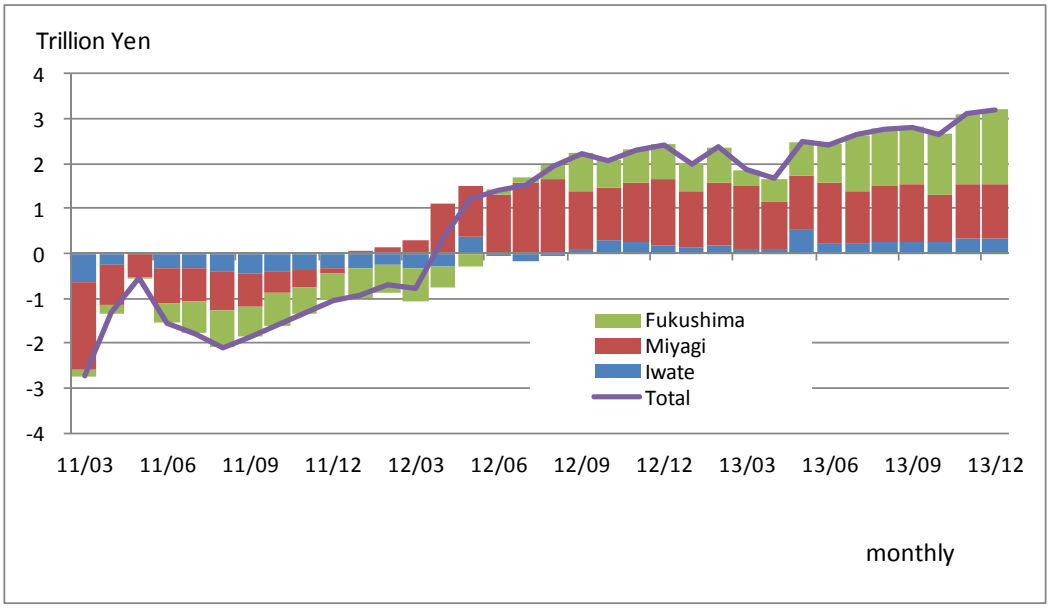
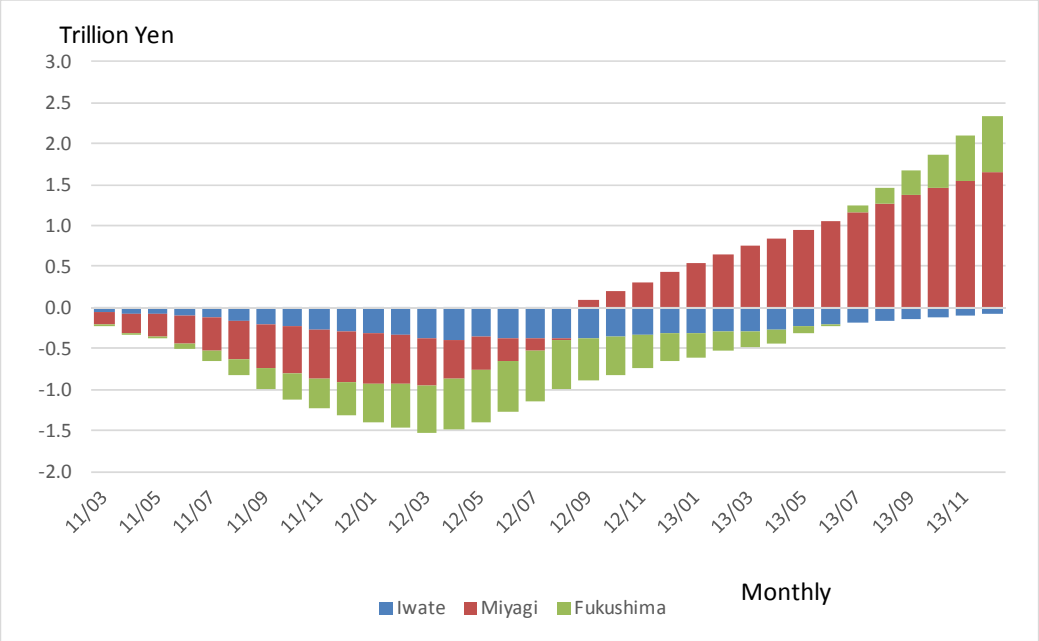


Figure 8 illustrates the accumulated reconstruction demand. By the end of 2013, it was approximately 2.5 trillion yen ($25 billion).

Figure 8 Accumulated reconstruction demand



4. Conclusion

In this study, we estimated the monthly GDP for 47 prefectures. We also estimated government consumption and net export. Further, we estimated the influence of the Great East Japan Earthquake and used monthly GDP and counterfactual data. The accumulated reconstruction demand was approximately 4 trillion yen ($40 billion) at the end of 2013.

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