How did workers adjust to labor demand shocks caused by the Great East Japan Earthquake?*

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December 9, 2016

Abstract

The Great East Japan Earthquake affected workers not only in the establishment that were directly damaged, but also those in their trading partners through the supply chain disruptions. I estimate the effect of such indirect shocks to workers on their job separation, employment status and geographical relocation in the following few years. Although the self-reported indicator of being affected by the earthquake are significantly correlated with negative outcomes such as high incidence of job separation, when the self-reported indicator is instrumented with proxy for the decline in production at the prefecture-industry level, the effects on labor market outcomes become weaker and mostly insignificant. The result implies that people who faced a negative employment shock may attribute it to the exogenous event, and this may cause substantial bias in the self-reported data on the effect of disasters.

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* Acknowledgement: This research is supported by Japan Society for the Promotion of Science (JSPS) Grant in Aid for Scientific Research (B) No. 15K17072 (PI: Ayako Kondo). The use of microdata was approved by the Statistics Bureau of the Ministry of Internal Affairs and Communications based on this grant. I also thank Mitsubishi Research Institute for sharing the inter-prefecture input-output table.

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1. Introduction

The Great East Japan Earthquake on March 11, 2011, and subsequent tsunami destroyed many buildings and resulted in about 15% reduction in industrial outputs.[1] Although the direct damages were concentrated to the three most affected prefectures, Iwate, Miyagi and Fukushima, businesses in other area of Japan were also affected through the supply chain disruptions. This decline in production led to a substantial decline in labor demand, at least in the short-run. Then, how did the workers adjust to such labor demand shocks?

During the months following the earthquake, popular press showed growing concern about widespread negative effect on employment, especially for non-regular workers, caused by the supply chain disruptions.[2] Nonetheless, there is no clear evidence for or against the existence of such indirect effect on employment. On the one hand, the existing studies on the effect of the Great East Japan Earthquake on employment focus on the three most affected prefectures (Higuchi et al. 2012, Ohta 2014) or people who were forced to evacuate (Genda 2014)[3]. On the other hand, many studies document the indirect effect through the supply chain disruptions on output (Okiyama et al 2012, Cavalho et al. 2014, Tokui et al 2015, Dekle et al 2016), but they ignore the effect on employment.[4]

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[1] Industrial Production Index, published by the Ministry of Economy, Trade and Industry, declined about 15% from February to March 2011, and remained flat in April.

[2] See, e.g. *Asahi shinbun*, March 29, 2011 (http://www.asahi.com/special/10005/TKY201103290116.html), *President*, May 2011 (http://president.jp/articles/-/3003), *Toyo-keizai online*, May 18, 2011 (http://toyokeizai.net/articles/-/6965) etc.

[3] Genda (2014) also examined who tend to report that their employment was affected by the earthquake; i.e., he uses the subjective indicator of being affected by the earthquake as a dependent variable, whereas I use it as an explanatory variable. He shows that men and youth are more likely to report that their job was affected by the quake, and college educated and regular employees are less likely to report that they lost job or their job was suspended.

[4] The only exception I am aware of is a research note by Nakano (2011). He estimates the impact of the decline in production on employment in 9 regions in Japan, using the inter-regional input-output table. However, as he acknowledges, his estimates are based on preliminary data that were available two months after the earthquake. Although his estimates for the nation-wide loss of employment ranges from 1.02% to 6.55 %, whereas the actual change in employment and wages turned out to be much smaller (Higuchi et al 2012, Ohta 2014).

This paper aims to fill this gap in the literature by examining the effect of labor demand shocks caused by the Great East Japan Earthquake on workers' job separation, employment status and geographical relocation in the following few years. Employment Status Survey (ESS) 2012 provide self-reported data on the effect of the Great East Japan Earth quake. About 8% of the workers experienced at least some short-term changes such as temporary suspension, shorter working hours and lower earnings. However, such self-reported data may be biased if some workers attribute negative shocks, which were actually caused by some other factors, to the earthquake. To solve this problem, I estimate the damage on production capacity at the industry-prefecture level based on the statistics on the direct physical damages to establishments and the inter-prefecture input-output table, and use it as an instrumental variable for the self-reported indicator of being affected by the earthquake.

The ordinary least squares estimator shows that individuals who report that their job was affected by the earthquake are more likely to have changed the job and moved to other prefectures. Moreover, as of October 2012, they are less likely to be on regular employment, and more likely to be unemployed or out of labor force. However, when the self-reported indicator is instrumented with proxy for the decline in production at the prefecture-industry level, the effects on labor market outcomes become weaker and mostly insignificant. This result implies that the self-reported data are biased, probably because workers or their employers who faced a negative shock attributed it to the earthquake, even if it is not the true cause.

I also show reduced form estimates of the effect of the estimated decline in production at the prefecture-industry level on employment outcomes in each quarter, using the monthly Labour Force Survey from April 2011 to March 2014. I do not find any statically significant effect even in the first few quarters, except for the job separation may have increased in 2011 if the three most affected prefectures are included. The actual impact of the Great East Japan Earthquake on the labor market is quite limited.

The rest of the paper is organized as follows. Section 2 explains data sources and how I constructed the variables. Section 3 describes the empirical model, and Section 4 presents the results. Section 5 concludes.

2. Data

2.1 Employment Status Survey 2012

The ESS is a cross sectional household survey conducted by the Statistics Bureau of Japan every five years. It asks about employment status and, if employed, job characteristics and earnings of each adult household member, as well as the basic demographic characteristics such as age, gender and educational background. Furthermore, information on the previous job is available for individuals who have ever quit a job. In addition to these regular questions, the EES conducted in October 2012 asked the effect of the Great East Japan Earthquake.

Using year and month when the individual started the current job and he/she quit the previous job, I retrieved information on the job held at the time of the earthquake. The survey also asks whether the individual has ever moved, and if yes, year and month of the move and the prefecture of the previous residence. Using these variables, the prefecture of residence at the time of earthquake is identified. Individuals with missing information and those who were not employed at the time of earthquake are dropped from the sample. The Appendix describes this data construction process in detail.

The question about the effect of the Great East Japan Earthquake on employment is "Were your main job at that time was affected by damages[5] to your workplace?," and the respondent choses one of the following answers: (1) not affected, (2) temporarily suspended, (3) lost the job permanently, (4) other (shorter working hours, wage cuts, etc.), and (5) not employed at that time. Those who chose (5) are dropped from the sample. Among those who were employed at the time of earthquake, only 0.2% lost their job permanently, but 3.1% were temporarily suspended and 4.7% experienced other influences such as shorter working hours and lower earnings. Based

[5] According to the survey instruction, "damages" include not only the direct physical damages and evacuation order but also damages to other branches of the company and supply chain disruptions. However, any effects of limits on electricity usage, including the planned outage, are not included. Moreover, it also includes the damages on the individual's family and house. Hence, I exclude those who had to evacuate from the sample because many of them were unable to continue working even if their employers were not affected by the earthquake.

on this question, I constructed an indicator for being affected, which takes 1 if the respondent answered (2), (3) or (4).[6]

Table 1 presents the summary statistics. In addition to the sample covering all prefectures in Japan, it also shows the sample excluding the three most affected prefectures (Iwate, Miyagi and Fukushima). Not surprisingly, excluding these three prefectures lowers the ratio of people who answered that their job was affected by the earthquake. The differences in other variables are negligible.

Figure 1 plots the ratio of people who answered that their employment was affected by the earthquake in each prefecture over the map. As expected, those who were affected are concentrated to northeast Japan, in particular the three most affected prefectures. That said, more than 3% of working population were affected in most part of Japan. As will be shown in Figure 3, there are substantial variations across industries, too.

2.2 Estimated damage at the industry-prefecture level

The self-reported effect on the earthquake on employment in the ESS may be incorrect if some workers attribute negative shocks, which were actually caused by some other factors, to the earthquake. That is, for example, people who had to leave their job for some other reasons may believe that they lost the job because of the earthquake. It is also possible that employers blame the earthquake for worse business conditions, even if it is not the true reason. Then, the self-reported effect on the earthquake on the employment may be correlated with unobservable negative shocks to employment status.

Thus, I instrument the self-reported indicator with an estimated damage from the earthquake, including the indirect effect from the supply chain disruption, at the industry-prefecture level constructed from various data sources. This variable should be independent of any negative shocks at the individual level caused by other reasons.

In the reminder of this subsection, I explain how I constructed this instrumental variable. I start with the estimation of the direct physical damage from tsunami and the nuclear power plant accident, and then describe how the indirect damages from

[6] As a robustness check, I replaced this indicator with an alternative indicator which takes 1 only if the job was suspended temporarily or lost permanently (i.e. (2) or (3)). The results do not change qualitatively.

the supply chain disruption are incorporated. Finally, I merge it with the ESS and present summary plots.

2.2.1 Direct physical damage from tsunami and the nuclear power plant accident

I constructed data for direct physical damage from the earthquake by 45 industries and 47 prefectures from various data sources. Since industries are coded in different ways in different data sources, I recoded industries to the 45 industries in the inter-prefecture input-output table, which will be used in the next subsection. To avoid confusion with other industry coding, hereafter I refer to the 45 industries as the I-O industries.

Let D_A^I denote the proportion of production facilities of I-O industry I in prefecture *A* made unavailable by the earth quake. D_A^I includes both physical damages by the tsunami and the evacuation order caused by the accident of Fukushima Daiichi nuclear power plant.[7] The official statistics for these damages are available at the municipality level, and I convert it to the I-O industry and prefecture level.

First, I defined the ratio of workers whose workplace is damaged by tsunami as follows. The Statistics Bureau of Japan published the number of workers employed by establishments in the area washed by tsunami, by municipalities and 19 major industries, on its website. However, the 19 major industries are too coarse; in particular, there is no subindustries within manufacturing while there was a large variation in the damage caused by tsunami across sectors within manufacturing. Therefore, I exploit the different employment composition of sectors in each municipality to capture the variation within manufacturing. Each sector's damage at the prefecture level is calculated as a weighted average of municipality-level damage rates with the employment share of each municipality within the sector-prefecture cell as the weight.

The Economic Census in 2009 provides the number of employees by 3-digit industry for each municipality. To obtain the estimated number of employees whose workplace was damaged by tsunami by 3 digit industries and municipalities, I multiply the number of all employees in each 3-digit-industry-munipality cell with the

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[7] I omit damages caused by the quake itself, because data by industry and municipality or prefecture are not available. I believe, however, this omission would not cause a serious problem since more than 90% of building damages were caused by tsunami, as summarized in chapter 3 of Saito (2015).

ratio of employees in the establishments washed by tsunami of the corresponding major industry and municipality.

Next, regarding the evacuation order due to the nuclear power plant accident, I assume that all establishments in the municipalities under the evacuation order[8] stopped production. Thus, for these municipalities, all workers in all industries are affected.

Then, I aggregate the estimated numbers of employees whose workplace was damaged by tsunami or nuclear power plant accident to the I-O industries and prefecture level. Let subscripts i, $\tilde{I}$, m denote a 3-digit industry included in I-O industry I, a major industry that includes I-O industry I, and a municipality included in prefecture A, respectively. $emp_{i,m}$ is the number of employees in 3-digit industry i and municipality m, $tsu_{\tilde{I},m}$ is the ratio of employees in the establishments washed by tsunami of major industry $\tilde{I}$ and municipality m, and eva_m be an indicator that takes 1 if municipality m is under the evacuation order. Then D_A^I is written as follows:

$$D_{A,tsu}^{I} = \frac{\sum_{m \in A} \sum_{i \in I} emp_{i,m} * \max\{tsu_{\tilde{I},m}, eva_m\}}{\sum_{m \in A} \sum_{i \in I} emp_{i,m}}$$

Obviously, the direct damage is concentrated to a few prefectures. The prefecture with the highest ratio of workers in establishments physically damaged by tsunami and the nuclear power plant accident is Miyagi (19.9%[9]), followed by Fukushima (13.6%), Iwate (11.2%), Aomori (5.9%) and Chiba (0.9%). The other prefectures were not affected by tsunami.

2.2.2 Upper bound of overall effect including indirect effect through supply chains

Using D_A^I defined in the last subsection, in this subsection I calculate the upper bound of indirect damage through the supply chain. The basic idea is that, if an input good from the area directly damaged by the earth quake were not substitutable with different good (i.e., the production function were Leontief) and firms were not able to procure the same good from other areas, the decline in the input caused by the direct

[8] Following Genda (2014), 11 municipalities are classified in this category: Tamura, Minamisoma, Kawamata, Naraha, Tomioka, Kawauchi, Okuma, Futaba, Namie, Kuzuo, and Iidate.

[9] Weighted average of D_A^I over industries with employment share of the industry as the weight.

damage from the earthquake would reduce the output proportionally. This approach is similar to “the first-stage bottleneck effect” by Tokui et al (2015).[10]

Of course, in reality, the production function is not Leontief, and the firm could also purchase the same input goods produced in other regions in Japan or import from abroad. Therefore, the estimated upper bound of damage should be interpreted as a very rough proxy that is correlated with the actual decline in production. This is why I use this variable as an instrument for the self-reported effect on employment, rather than an explanatory variable.

Specifically, let I_{AB}^{IJ} denote the purchase of input goods from industry I in prefecture A by industry J in prefecture B.[11] Then, the ratio of input goods purchased from the area affected by the earth quake in the total purchase from industry I by industry J in prefecture B can be written as follows:

$$\widetilde{D}_B^{IJ} = \frac{\sum_p I_{pB}^{IJ} D_p^I}{\sum_p I_{pB}^{IJ}}$$

This is a weighted average of direct damage in the input sector, with the share of each prefecture in the total input as the weight.

Then, I define the upper bound of the decline in output in industry J in prefecture B caused by the earth quake as the maximum of the direct physical damage to the industry J in prefecture B or the damage to each input good. Let dam_B^J denote this upper bound in the form of the share in total output of industry J in prefecture B, it can be written as follows:

Among the existing studies on the indirect effect of the Great East Japan Earthquake through the supply chain disruptions on output, Tokui et al (2015) is the closest to this study in the sense that they explicitly distinguish tsunami-affected prefectures from the rest of Tohoku and Kanto, in addition to the assumption of Leontief production technology. While other studies use the inter-regional input-

[10] An important difference is that I ignore the second and higher order impact for simplicity, as my main purpose is not to obtain an accurate estimate for the production loss.

[11] This inter-prefecture input-output table was developed by Mitsubishi Research Institute, based on inter-regional input-output table 2005 published by Ministry of Economy, Trade and Industry. This is an updated version of the input-output table based on 2000 data by Miyagi et al (2003), and also used by Okiyama et al (2012). Tokui et al (2015) seems to have used a different prefercture-level input-output table, but the table they used is also based on the inter-regional input-output table 2005.

output table (Dekle et al 2016) or firm level data (Cavalho et al 2014), regardless of the unit of observation, all of these existing studies show substantial effects on output caused by the supply chain disruptions. I chose to use the inter-prefecture input-output table rather than the inter-regional one, because 9 regions are too coarse to control for industry fixed effects.

2.2.3 Merging to the ESS

The estimated damage from the earthquake can be merged with individual level data if the industry and prefecture at the time of the earthquake are available. Such variables are available in the ESS; however, the industry of the previous job are available only at the major 19 industries. Therefore, the 45 industries have to be aggregated to the major industries. This is an important limitation of the ESS data, and, as will explained in the next subsection, I use another dataset to check whether aggregating industries changes the results qualitatively. The crosswalk of industry codes is presented in the Appendix.

Figure 2 plots the average dam_B^J of workers who lived in each prefecture at the time of earthquake, using the merged data. Just like Figure 1, the damages are concentrated to the northeast region, in particular the three most affected prefectures. However, the distribution of dam_B^J is less widespread than the self-reported indicator shown in Figure 1. While prefectures in the middle part of Japan, such as Nagano, are substantially affected, the estimated damages are almost negligible in the south west part of Japan.

Furthermore, there are substantial variation across industries. Figure 3 is the scatter plot of the subjective index and the estimated damage by 18 major industries. The two variables are positively correlated, and both are high in manufacturing, the industry most affected by the supply chain disruptions.

2.3 Monthly Labour Force Survey (LFS)

An important limitation of the ESS is that the industry of the previous job is available only at the 19 major industry level. Substantial variation in the estimated damage from the earthquake may lost by aggregating the 45 industries in the inter-prefecture input-output table to the 19 major industry. In particular, there is no subsectors within the manufacturing in the ESS, whereas the 45 industries in the

Input-output table include 23 subsectors in manufacturing, and there are substantial variations across them.

To check if this aggregation changes the results qualitatively, I use the Labour Force Survey (LFS) for supplemental analyses. The LFS is a cross sectional survey conducted monthly by the Statistic Bureau of Japan. The special questionnaire, distributed to about 25,000 individuals each month, asks the detailed employment status (regular or non-regular) and information on the previous job if the individual quit a job in the last three years, in addition to the demographic characteristics available from the basic questionnaire. Although the self-reported data on the effect of the earthquake on employment are not available, it is feasible to merge the estimated damage from the earthquake at the industry-prefecture level. Unlike the ESS, the industry of the previous job is available at a finer level, and the classification within manufacturing is almost the same as that in the input-output table. Thus I can exploit the variation in dam_B^J within the manufacturing sector.

Unlike the ESS, however, I have to use the prefecture of current residence because there is no other information on the residential location. Thus, as the time between the earthquake and the survey date becomes longer, the measurement errors in the prefecture increase. Moreover, the information on the previous job is not available if the individual quit the job more than three years ago. Thus, I limit the data period to April 2011-March 2014, the first three years after the earthquake.

The last two columns of Table 1 report summary statistics. Note that the survey was not conducted in the three most affected prefectures until September 2011, thus data of all prefectures cover September 2011-March 2014, whereas data excluding the three most affected prefectures cover April 2011-march 2014. Since the time from the earthquake is on average longer for the LFS sample, more people left the labor force or changed the job since the earthquake, but other variables are very similar to the ESS.

3. Empirical model

3.1 OLS and IV estimates of the effect of being affected by the earthquake on status as of October 2012 using the ESS

I estimate the following linear model:

$$Y_{ijp} = \beta_0 + \beta_1 D_{ijp} + \beta'_2 X_{ijp} + \theta_j + \lambda_p + \varepsilon_{ijp}$$

where Y_{ijp} represents one of the following outcome variables for individual i who worked in industry j and lived in prefecture p in March 2011: indicators for having left the job held in March 2011, having moved to other prefecture, regular employment, unemployment and out of labor force as of October 2012. D_{ijp} is a dummy variable that takes 1 if the individual reported that his or her job was affected by the earthquake. X_{ijp} is a vector of explanatory variables including female dummy, education dummies, potential experience and its square. θ_j and λ_p represent industry- and prefecture- fixed effects, respectively, and ε_{ijp} are remaining errors. Standard errors are clustered at the industry-prefecture level.

As already mentioned, D_{ijp} may be correlated with ε_{ijp} if the individual or his/her employer attributes negative shocks caused by other factors to the earthquake. To solve this endogeneity problem, I instrument D_{ijp} with dam_p^j, the estimated upper bound of the decline in output in industry j in prefecture p caused by the earth quake. The first stage is defined as follows:

$$D_{ijp} = \gamma_0 + \gamma_1 \mathrm{dam}_p^j + \gamma'_2 X_{ijp} + \mu_j + \eta_p + \xi_{ijp}$$

The estimated γ_1 in the first stage regressions are presented in the Appendix. The instrument has enough explanatory power.

3.2 Reduced form estimates of the coefficients of the estimated damage from tsunami and new clear power plant accident using the LFS

As explained in Section 2.3, the LFS allows me to exploit variation in dam_p^j across subsectors with manufacturing. The reduced form model is specified as follows:

$$Y_{ijp} = \alpha_0 + \alpha_1 \mathrm{dam}_p^j + \alpha'_2 X_{ijp} + \theta_j + \lambda_p + \varepsilon_{ijp}$$

Recall that dam_p^j may substantially overstate the accrual decline in production, thus the size of α_1 does not have much information. However, the sign and statistical significance of α_1 is informative.

Another advantage of the LFS is that I can follow changes in α_1 over time. Specifically, in addition to the pooled sample of April (September) 2011-December 2012, I divide the sample to quarters, estimate the same equation using each subsample, and plot it over time.

4. Results

4.1 Comparison between OLS and IV estimates

Table 2 presents the estimated coefficient of the self-reported indicator for being affected by the quake, β_1 in equation (), for various combinations of outcome variables and samples. Each cell corresponds to a different regression. It shows that people who answered that their job was affected by the earthquake tend to have left the job and moved to other prefectures. Furthermore, they are less likely to be on regular employment, and more likely to be unemployed or out of labor force.

A naïve interpretation of Table 2 is that the Great East Japan indeed had a substantial negative impact on workers in the sector and region that were affected, including those affected through the supply chain disruptions. The difference between the full sample and the sample excluding the three most affected prefectures are small and nonsystematic, implying that this results are not driven by people who were directly damaged.

However, when the self-reported indicator is instrumented with the estimated damage at the industry-prefecture level, such effects disappear. Table 3 shows the estimated coefficient in the IV regression, γ_1 in equation (). The effects on job separation and geographical relocation are not statistically significant and varying in sign. The effects on employment status seems to be rather positive for men and zero for women. These results imply that the decline in production capacity right after the earthquake did not have long-term effects on workers in the affected sectors.

Tables 4 and 5 repeat the same exercise using the subsample of workers who were on non-regular employment at the time of the earthquake. Results are qualitatively the same for the full sample results. Despite the impression from popular press that many non-regular workers lost their job due to the decline in production caused by the earthquake and supply chain disruptions, long-term effects were actually negligible. The Appendix shows the results do not change for other subsamples whose employment are thought to be less protected, such as youth, elderly, and less educated workers.

The stark contrast between the OLS and IV results imply that whether an individual thinks his or her job was affected by the earthquake is strongly correlated with random shocks in employment as of October 2012. This may be because people who faced a negative shock tend to attribute it to exogenous events to avoid blaming themselves. Another possibility is that the employers, rather than the workers, used the earthquake as an excuse for downsizing or wage cuts.

Such self-justification of employers and workers can also reconcile the apparently contradicting press reports that many people lost their jobs due to the earthquake. That is, the worker or employer believes that the earthquake caused the trouble, even if it is not the true cause, and the media tells the story consistent to such belief.

4.2 Reduced form estimates and changes over time

As explained in Section 2.2.3, the industry of the previous job in the ESS is available only at the major industry level. Aggregating the 45 I-O industries to the 19 major industries loses substantial variation within each prefecture. To exploit such variation, in particular the variation across subsectors of manufacturing, I estimate the reduced form effects of the estimated damage at the industry-prefecture level on individual workers' outcomes using the LFS.

Table 6 presents the estimates from the sample covering April or September 2011-December 2012. There is no statistically significant effect, except that the probability of leaving the job increases when the three most affected prefectures are included. This results implies that the lack of the statistical significant effects from the IV model with the ESS is not caused by the loss of variation in the instrument within each prefecture.

Figure 4 plots the estimates from subsamples by quarter, extended up to March 2014. Except for some increase in the probability of leaving the job in the first few quarters, there is no systematic pattern and most of the estimated coefficients are statistically insignificant. Even in the first few quarters, there is no clear evidence for any negative impact on employment status. Although it may be true that the disruption in production was temporary, even temporary shocks to employment status are not observed.

5. Conclusion

Existing studies on the Great East Japan Earthquake has shown that the supply chain disruptions affected economic activities of firms outside of the directly affected areas. This paper examined whether such disruptions in production process affect employment, and found no significant effects on employment status. The effect of the Great East Japan Earthquake on the labor market outside of the directly affected area seems to be negligible.

This paper also shows that, even though the self-reported data show strong correlation between the effect of the earthquake on the job and employment status one and half year later, such correlation is spurious. A lesson from this is that a naïve use of self-reported data may overstate the impact of natural disasters, or any exogenous shocks, on individuals' economic outcomes. It is particularly important for policy makers to be aware of such biases, since the overstatement of the impact of natural disasters may lead to excessively large spending on rehabilitation projects.

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Table 1 Summary statistics

	ESS		LFS	
	All prefectures	Excluding the three most affected prefectures	All prefectures, September 2011-March 2014	Excluding the three most affected prefectures, April 2011-March 2014
Sample size	478,480	451,643	306,465	338,897
Effect of the earthquake in the job held at the time of earthquake				
Job was affected by the earthquake (self-reported)	7.99%	6.25%	NA	NA
Temporary suspension or permanent job loss (self-reported)	3.28%	2.12%	NA	NA
Estimated damage from tsunami and new clear power plant accident at the industry-prefecture level (calculated based on external sources, see Section 2.2)	9.09%	6.11%	9.5%	6.6%
Status as of survey date				
Left the job held at the time of the earthquake	9.84%	9.83%	14.2%	12.6%
Relocated to other prefectures	1.40%	1.43%	NA	NA
Employed	95.22%	95.20%	93.3%	93.9%
Regular employment	49.48%	49.44%	49.8%	50.2%
Unemployed	1.86%	1.87%	2.2%	2.1%
Out of labor force	2.92%	2.93%	4.5%	4.0%
Demographic characteristics				
Female	43.20%	43.23%	43.6%	43.6%

Potential experience	30.89	30.87	30.09	29.94
Age	48.67	48.65	47.97	47.82
Education: Junior high school	11.66%	11.49%	}58.23%	}57.64%
Education: high school	44.79%	44.46%		
Education: vocational school (*senmon*)	12.29%	12.23%	}18.08%	}18.19%
Education: Junior college	8.86%	9.02%		
Education: four year college or graduate school	21.70%	22.09%	23.69%	24.18%

Note: the sample is limited to those who were employed at the time of the earthquake, and all necessary variables are available.

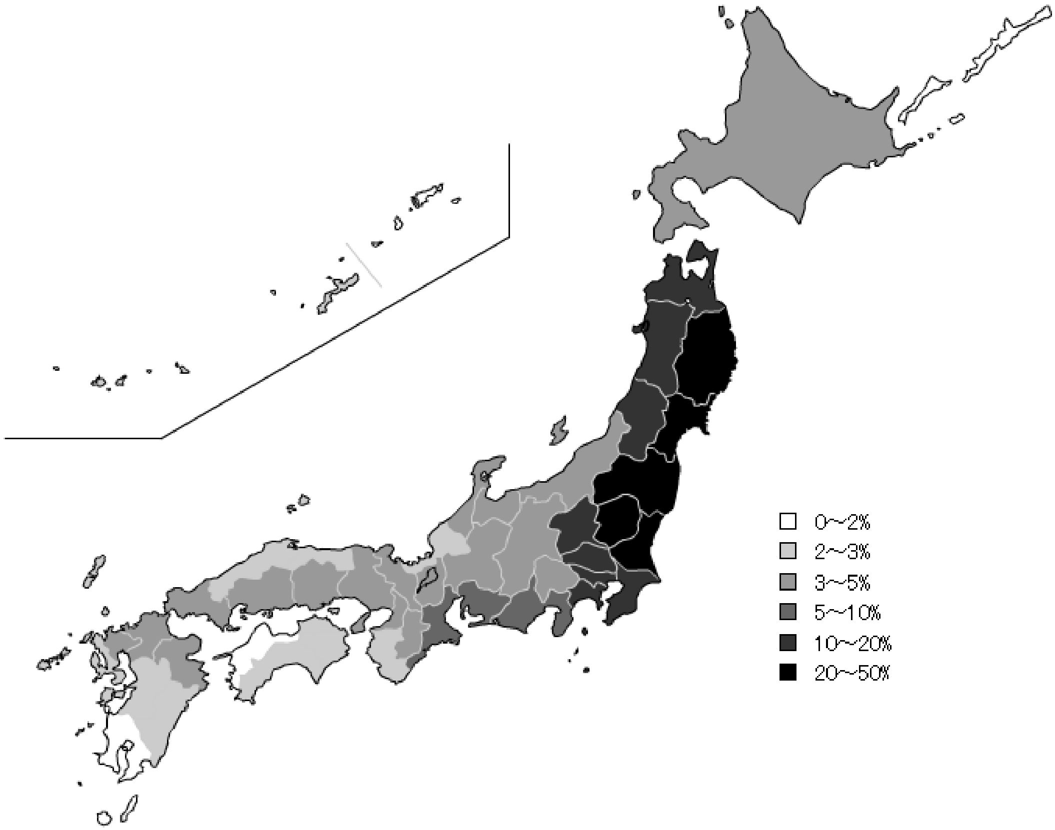

Figure 1: Geographical distribution of workers who answered that their employment was affected by the Great East Japan Earthquake

Note: Average of individuals in each prefecture from the ESS. The sample is restricted to individuals who were employed as of March 2011 and did not evacuate. Sampling weights are applied.

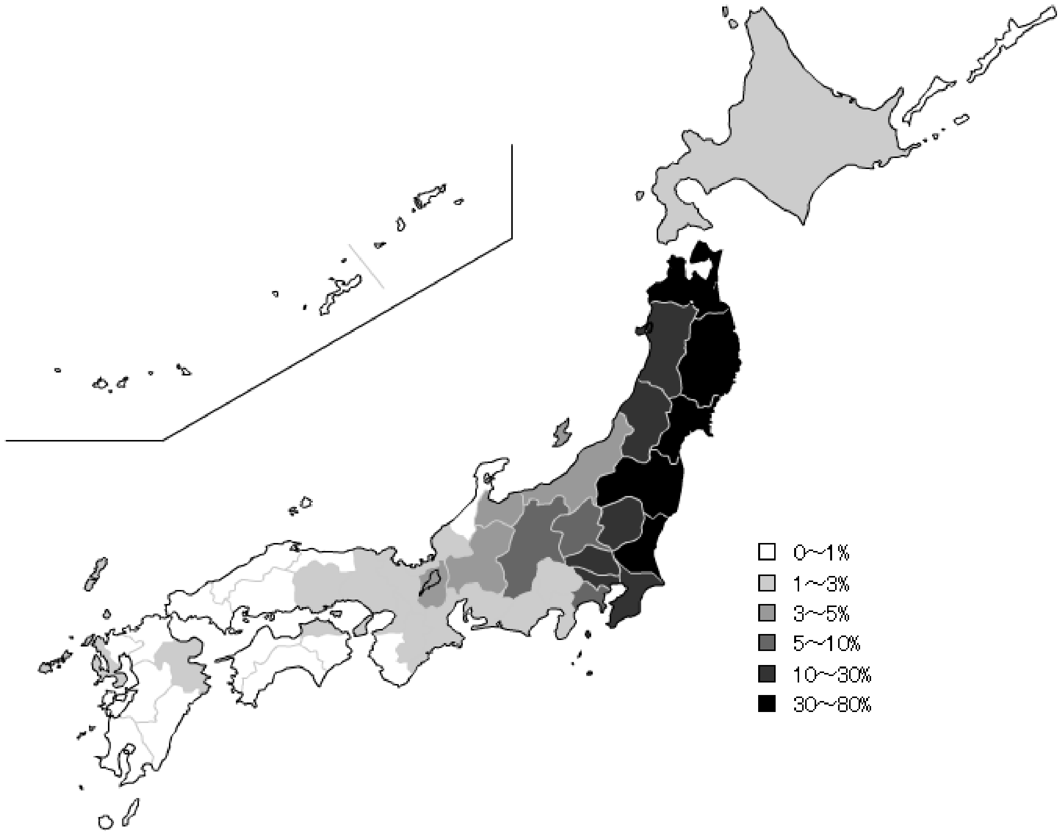

Figure 2: Geographical distribution of the estimated damage from tsunami and new clear power plant accident

Note: Average of individuals in each prefecture from the ESS. The sample is restricted to individuals who were employed as of March 2011 and did not evacuate. Sampling weights are applied.

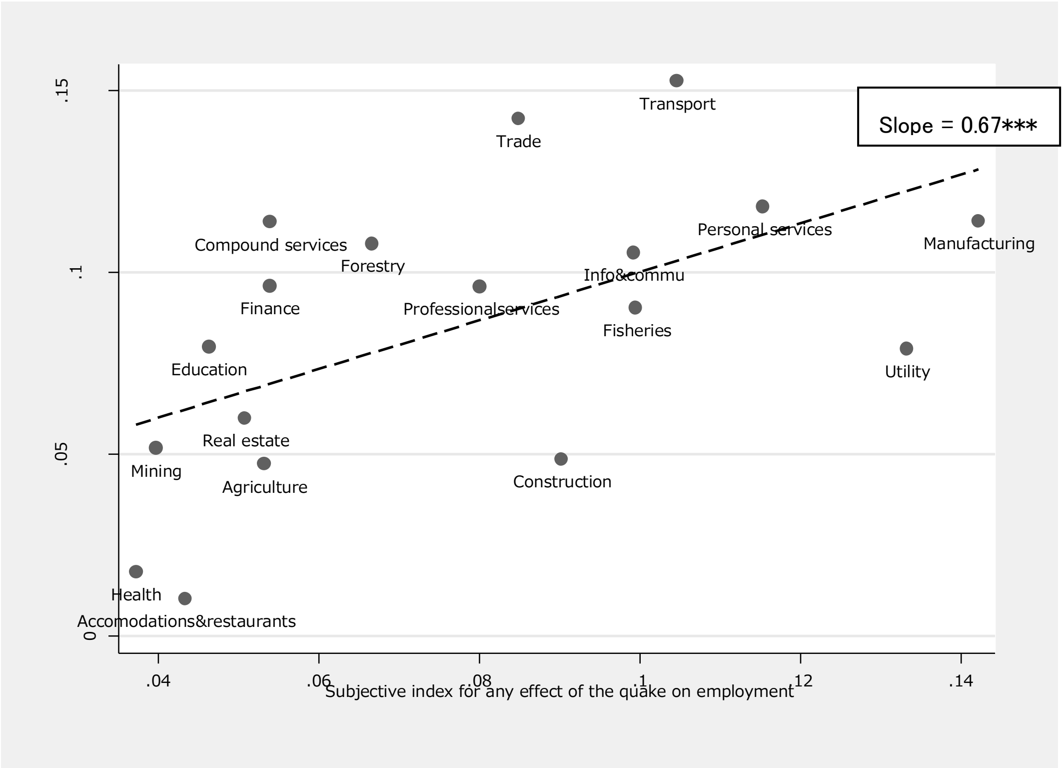

Figure 3: Industry-level correlation between the self-reported index for any effect of the quake on employment and the estimated damage from tsunami and power plant accident

Note: each point represents the average of individuals in each industry from the ESS. The sample is restricted to individuals who were employed as of March 2011. Those who were still evacuating as of the survey date are excluded. Sampling weights are applied.

Table 2 OLS estimates of the coefficients of the self-reported index for any effect of the quake on employment on various employment outcomes

	All prefectures		Excluding the three most affected prefectures	
Dependent variable	Male	Female	Male	Female
Left the job held at the time of	0.013***	0.038***	0.010***	0.034***
the earthquake	[0.003]	[0.005]	[0.003]	[0.006]
Relocated to other prefectures	0.006***	0.004**	0.007***	0.005**
	[0.001]	[0.001]	[0.002]	[0.002]
Regular employment	-0.025***	-0.027***	-0.019***	-0.018***
	[0.006]	[0.007]	[0.006]	[0.007]
Unemployed	0.005***	0.012***	0.006***	0.011***
	[0.001]	[0.002]	[0.001]	[0.002]
Out of labor force	0.003**	0.009***	0.003***	0.009***
	[0.001]	[0.001]	[0.001]	[0.002]
Sample size (same for all rows)	271,781	206,699	256,393	195,250

Data: ESS 2012

Note: Each cell corresponds to a different regression. Other explanatory variables omitted from the table are female dummy, potential experience and its square, education dummies, dummies for prefecture of residence at the time of earth quake, and industry of the job at the time of earthquake. Standard errors clustered at the prefecture level are in the brackets. *, **, *** indicates statistical significance at the 10%, 5% and 1% level, respectively.

Table 3 IV estimates of the coefficients of the self-reported index for any effect of the quake on employment on various employment outcomes (IV: the estimated damage from tsunami and new clear power plant accident)

	All prefectures		Excluding the three most affected prefectures	
Dependent variable	Male	Female	Male	Female
Left the job held at the time of	-0.014	0.025	-0.047	-0.032
the earthquake	[0.043]	[0.036]	[0.074]	[0.053]
Relocated to other prefectures	0.01	-0.001	-0.032	0.008
	[0.028]	[0.009]	[0.029]	[0.018]
Regular employment	0.291**	0.061	0.446*	0.099
	[0.138]	[0.067]	[0.240]	[0.119]
Unemployed	-0.026	-0.031	-0.053	-0.05
	[0.027]	[0.020]	[0.047]	[0.037]
Out of labor force	-0.055**	0.023	-0.052*	0.023
	[0.024]	[0.014]	[0.031]	[0.026]
Sample size (same for all rows)	271,781	206,699	256,393	195,250

Note: Each cell corresponds to a different regression. Other explanatory variables omitted from the table are female dummy, potential experience and its square, education dummies, dummies for prefecture of residence at the time of earth quake, and industry of the job at the time of earthquake. Standard errors clustered at the prefecture level are in the brackets. *, **, *** indicates statistical significance at the 10%, 5% and 1% level, respectively.

Table 4 OLS estimates of the coefficients of the self-reported index for any effect of the quake on employment on various employment outcomes, non-regular employees at the time of the earthquake

	All prefectures		Excluding the three most affected prefectures	
Dependent variable	Male	Female	Male	Female
Left the job held at the time of	0.023***	0.040***	0.022***	0.035***
the earthquake	[0.004]	[0.006]	[0.005]	[0.007]
Relocated to other prefectures	0.005**	0.003	0.007**	0.004*
	[0.003]	[0.002]	[0.003]	[0.003]
Regular employment	0.002	0.002**	0.001	0.002
	[0.002]	[0.001]	[0.002]	[0.001]
Unemployed	0.007***	0.013***	0.009***	0.012***
	[0.002]	[0.002]	[0.003]	[0.003]
Out of labor force	0.005**	0.010***	0.005*	0.009***
	[0.002]	[0.003]	[0.003]	[0.003]
Sample size (same for all rows)	103,661	125,725	97,770	118,859

Data: ESS 2012

Note: Each cell corresponds to a different regression. Other explanatory variables omitted from the table are female dummy, potential experience and its square, education dummies, dummies for prefecture of residence at the time of earth quake, and industry of the job at the time of earthquake. Standard errors clustered at the prefecture level are in the brackets. *, **, *** indicates statistical significance at the 10%, 5% and 1% level, respectively.

Table 5 IV estimates of the coefficients of the self-reported index for any effect of the quake on employment on various employment outcomes (IV: the estimated damage from tsunami and new clear power plant accident), non-regular employees at the time of the earth quake

	All prefectures		Excluding the three most affected prefectures	
Dependent variable	Male	Female	Male	Female
Left the job held at the time of	0.007	0.054	-0.066	0.027
the earthquake	[0.069]	[0.042]	[0.132]	[0.070]
Relocated to other prefectures	0.002	0.003	0.011	0.014
	[0.016]	[0.010]	[0.040]	[0.019]
Regular employment	0.041	-0.024	0.111	-0.029
	[0.028]	[0.016]	[0.077]	[0.025]
Unemployed	-0.022	-0.018	-0.111*	-0.033
	[0.029]	[0.020]	[0.066]	[0.036]
Out of labor force	-0.031	0.02	-0.046	-0.004
	[0.034]	[0.022]	[0.086]	[0.037]
Sample size (same for all rows)	103,661	125,725	97,770	118,859

Note: Each cell corresponds to a different regression. Other explanatory variables omitted from the table are female dummy, potential experience and its square, education dummies, dummies for prefecture of residence at the time of earth quake, and industry of the job at the time of earthquake. Standard errors clustered at the prefecture level are in the brackets. *, **, *** indicates statistical significance at the 10%, 5% and 1% level, respectively.

Table 6 Reduced form estimates of the coefficients of the estimated damage from tsunami and new clear power plant accident on various employment outcomes

	Left the job held at the time of earthquake	Regular employment	Unemployed	Out of labor force
All prefectures, September 2011-December2012 (sample size: 165,138)	0.021**	0.025	0.005	0.005
	[0.010]	[0.018]	[0.004]	[0.006]
Excluding the three most affected prefectures, April 2011- December 2012 (sample size: 205,469)	0.003	0.021	-0.001	-0.004
	[0.008]	[0.020]	[0.004]	[0.005]

Note: Each cell corresponds to a different regression. Other explanatory variables omitted from the table are female dummy, potential experience and its square, education dummies, dummies for prefecture of residence as of survey date, and industry of the job at the time of earthquake. Standard errors clustered at the prefecture level are in the brackets. *, **, *** indicates statistical significance at the 10%, 5% and 1% level, respectively.

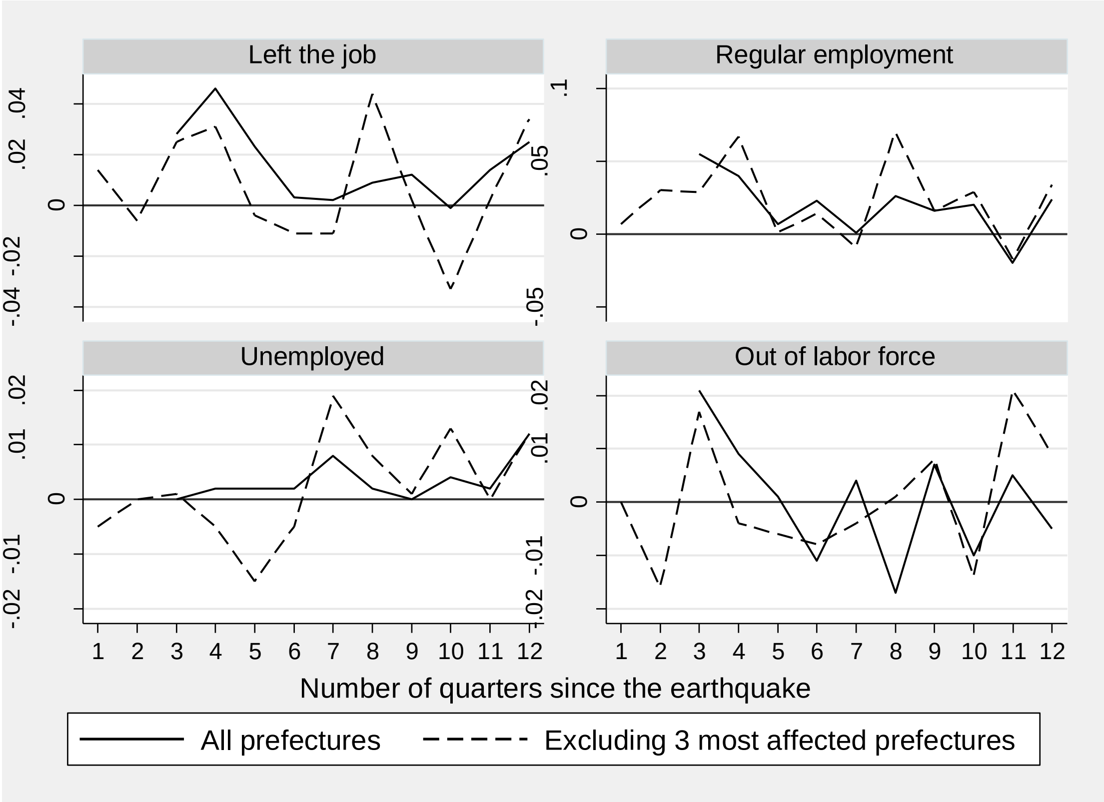

Figure 4 Quarter-by-quarter estimates of the coefficients of the estimated damage from tsunami and new clear power plant accident on various employment outcome

Appendix （incomplete）

A1. Sample restrictions and identification of the job held at the time of the earthquake

The raw data of the ESS include more than 950,000 individuals older than 15. From them, I exclude those who were forced to evacuate because many of them were unable to continue working because of the damages to their families and houses, rather than their employers.

Next, I made the variable “prefecture of residence at the time of earthquake” based on the following variables: when the individual started to live in the current residence, and the prefecture of the previous residence. If the individual started to live in the current residence before March 2011, the current residence is the residence at the time of earthquake. If the individual started to live in the current residence after April 2011, I assume that the previous residence is the residence at the time of earthquake. Those with missing information on these variables are dropped from the sample.

Then, I limit the sample to those who had a job at the time of the earthquake, and answered to the question on the effect of the earthquake on employment. At this point, the sample size becomes about a half of the raw data.

For those who were employed at the time of the earthquake, I retrieve the information on the job at the time of earthquake in the following way. First, if the individual was employed as of the survey date and started the current job before March 2011, the current job is the job held at the time of the earthquake. Next, for individuals who started the job after April 2011or were not employed as of the survey date, I checked if the previous job is the job held at the time of the earthquake using the information on the year and month when the individual quit the previous job and the tenure of the previous job. 13,144 individuals are dropped because these variables are missing and 9,614 are dropped because they started their previous job after April 2011 (i.e. the individual has changed jobs more than twice since then).

Lastly, individuals whose job at the time of earthquake was public sector or unclassified industry are dropped, because the estimated damages at the industry-prefecture level are not available for them, and those with missing age and education are also dropped. Appendix Table A1 summarizes the number of dropped observations and remaining sample size.

The LFS doesn’t ask questions about evacuation or residential location. Thus, I have to use the prefecture of the current residence as a proxy for the prefecture of residence at the time of the earthquake. Regarding the job held at the time of the earthquake, the LFS has information on the current and the previous job like the ESS does, so I retrieved it in the same way.

A2. Industry crosswalk

Appendix Table A2

A3. First stages

Appendix Table A3.

A4. Subsample analysis

I estimate the same model as the main results (Tables 2 and 3) with the following subsamples: youth, elderly and high school or less educated. These groups are less protected by the so called "life-time employment" system, and thus they are expected to be more vulnerable to negative employment shocks caused by the earthquake.

Appendix Tables A4 and A5 show the results. Overall, the results are very similar to the full-sample results: the OLS estimates are statistically significant but the IV estimates are insignificant. The only exceptions are that the IV estimates of the effect on job separation is statistically significantly positive for youth, and the effects on regular employment and out of labor force are also significant for young women. However, these are no longer statistically significant when the three most affected prefectures are excluded from the sample.

Appendix Table A1: Sample restrictions on the ESS

	Dropped observations	Remaining sample size
Raw data		956,564
Forced to evacuate	18,345	938,219
Residence at the time of earthquake unavailable	13,364	924,855
Non response to the question about the effect of the earthquake on employment	8,276	916,579
Not working at the time of the earthquake	402,857	513,722
Missing employment history	13,144	500,578
Unable to identify employment status at the time of the earthquake because the individual has changed jobs more than twice since then	9,614	490,964
The job at the time of earthquake was public sector or unclassified industry	10,155	480,809
Age or education is missing	2,329	478,480

Appendix Table A2 Industry crosswalk

<table>
<tr><th colspan="2">Employment Status Survey</th><th colspan="2">Inter-prefecture input-output table</th><th colspan="2">Labour Force Survey</th></tr>
<tr><td>1</td><td>Agriculture</td><td>1</td><td>Agriculture</td><td>01</td><td>Agriculture</td></tr>
<tr><td>2</td><td>Forestry</td><td>2</td><td>Forestry</td><td>02</td><td>Forestry</td></tr>
<tr><td rowspan="2">3</td><td rowspan="2">Fishery</td><td rowspan="2">3</td><td rowspan="2">Fishery</td><td>03</td><td>Fishery except aquaculture</td></tr>
<tr><td>04</td><td>Aquaculture</td></tr>
<tr><td>4</td><td>Mining</td><td>4</td><td>Mining</td><td>05</td><td>Mining and quarrying of stone and gravel</td></tr>
<tr><td rowspan="2">5</td><td rowspan="2">Construction</td><td>29</td><td>Construction</td><td rowspan="2">06</td><td rowspan="2">Construction</td></tr>
<tr><td>30</td><td>Public engineering</td></tr>
<tr><td rowspan="18">6</td><td rowspan="18">Manufacturing</td><td rowspan="2">5</td><td rowspan="2">Food and tobacco</td><td>09</td><td>Food</td></tr>
<tr><td>10</td><td>Beverages, tobacco and feed</td></tr>
<tr><td>6</td><td>Textile</td><td>11</td><td>Textile mill products</td></tr>
<tr><td>7</td><td>Lumber and wood products</td><td>12</td><td>Lumber and wood products, except furniture</td></tr>
<tr><td>8</td><td>Furniture and fixtures</td><td>13</td><td>Furniture and fixtures</td></tr>
<tr><td>9</td><td>Pulp, paper and paper products</td><td>14</td><td>Pulp, paper and paper products</td></tr>
<tr><td>10</td><td>Printing and publishing</td><td>15</td><td>Printing and allied industries</td></tr>
<tr><td>11</td><td>Chemical and allied products</td><td>16</td><td>Chemical and allied products</td></tr>
<tr><td>12</td><td>Petroleum and coal products</td><td>17</td><td>Petroleum and coal products</td></tr>
<tr><td>13</td><td>Plastic products</td><td>18</td><td>Plastic products, except otherwise classified</td></tr>
<tr><td>14</td><td>Rubber products</td><td>19</td><td>Rubber products</td></tr>
<tr><td>15</td><td>Leather products</td><td>20</td><td>Leather tanning, leather products and fur skins</td></tr>
<tr><td>16</td><td>Ceramic, stone and clay products</td><td>21</td><td>Ceramic, stone and clay products</td></tr>
<tr><td>17</td><td>Iron and steel</td><td>22</td><td>Iron and steel</td></tr>
<tr><td>18</td><td>Non-ferrous metals</td><td>23</td><td>Non-ferrous metals and products</td></tr>
<tr><td>19</td><td>Metal products</td><td>24</td><td>Fabricated metal products</td></tr>
<tr><td>20</td><td>General machinery</td><td>25</td><td>General-purpose machinery</td></tr>
</table>

				26	Production machinery
		21	Machinery for office and service industry	27	Business oriented machinery
		27	Precision instruments		
		23	Information and communication electronics equipment	28	Electronic parts, devices and electronic circuits
				30	Information and communication electronics equipment
		22	Household electric appliances	29	Electrical machinery, equipment and supplies
		24	Other electrical equipment		
		25	Cars	31	Transportation equipment
		26	Other transportation equipment		
		28	Miscellaneous manufacturing products	32	Miscellaneous manufacturing industries
7	Electricity, Gas, Heat supply and Water	31	Electricity	33	Electricity, Gas, Heat supply and Water
		32	Gas and heat supply		
		33	Water supply and waste disposal business		
	NA	33	Water supply and waste disposal business	88	Waste disposal business
8	Information and communications	38	Communication and broadcasting	37	Communications
				38	Broadcasting
				39	Information services
				40	Internet based services
				41	Video picture, sound information, Character information production and distribution
9	Transport and postal activities	37	Transport	42	Railway transport
				43	Road passenger transport

				44	Road freight transport
				45 46	Water transport Air transport
				47	Warehousing
				48	Services incidental to transport
			NA	49	Postal activities
10	Wholesale and Retail trade	34	Commerce	50	Wholesale trade
				56	Retail trade, general merchandise
				57	Retail trade (dry goods, apparel and apparel accessories)
				58	Retail trade (food and beverage)
				59	Machinery and equipment
				60	Miscellaneous retail trade
11	Finance and Insurance	35	Finance and Insurance	62	Finance and Insurance
12	Real estate and goods rental and leasing	36	Real estate	68	Real estate
				70	Goods rental and leasing
13 & 19	Scientific research, professional and technical services & Services, N.E.C	43	Business services	71	Scientific and development research institutes
				72	Professional services, N.E.C
				73	Advertising
				74	Technical services, N.E.C
				89	Automobile maintenance services
				90	Machine, ETC. repair services, except otherwise
				91	Employment and worker dispatching services
				92	Miscellaneous business services
				79	Miscellaneous living-related and personal services

				80	Services for amusement and hobbies
16	Education, learning support	40	Education and research	81	School education
				82	Miscellaneous education, learning support
17	Medical, health care and welfare	41	Medical service, health, social security and nursing care	83	Medical and other health services
				84	Public health and hygiene
				85	Social insurance and social welfare
18	Compound services	42	Other public services	86	Postal services
				87	Cooperative association, N.E.C
				93	Political, business and cultural organizations
				94	Religion

Appendix Table A3: First stage estimates

	All prefectures		Excluding the three most affected prefectures	
Sample	Male	Female	Male	Female
All	0.121***	0.208***	0.100***	0.169***
	[0.028]	[0.030]	[0.030]	[0.029]
Non regular employees	0.161***	0.232***	0.095***	0.190***
	[0.041]	[0.031]	[0.030]	[0.024]
Youth	0.128***	0.256***	0.103**	0.232***
	[0.035]	[0.036]	[0.049]	[0.039]
Elderly	0.138***	0.228***	0.066***	0.170***
	[0.044]	[0.030]	[0.018]	[0.029]
High school	0.166***	0.233***	0.119***	0.186***
or less educated	[0.035]	[0.031]	[0.025]	[0.027]

Appendix Table A4: Replication of Table 2 (OLS) with subsamples

A. Youth (age<=35 at the time of earthquake)

	All prefectures		Excluding the three most affected prefectures	
Dependent variable	Male	Female	Male	Female
Left the job held at the time of	0.013***	0.036***	0.012**	0.035***
the earthquake	[0.005]	[0.010]	[0.005]	[0.012]
Relocated to other prefectures	0.013***	0.009***	0.014***	0.010**
	[0.003]	[0.003]	[0.003]	[0.004]
Regular employment	-0.014*	-0.032**	-0.011	-0.022**
	[0.007]	[0.012]	[0.008]	[0.010]
Unemployed	0.004**	0.014***	0.006**	0.012***
	[0.002]	[0.003]	[0.002]	[0.004]
Out of labor force	0.001	0.008**	0.001	0.010**
	[0.001]	[0.004]	[0.001]	[0.004]
Sample size (same for all rows)	59,511	48,108	56,194	45,477

B. Elderly (age>=60 at the time of earthquake)

	All prefectures		Excluding the three most affected prefectures	
Dependent variable	Male	Female	Male	Female
Left the job held at the time of	0.031***	0.039***	0.032***	0.024**
the earthquake	[0.006]	[0.010]	[0.008]	[0.009]
Relocated to other prefectures	0.003***	0.002	0.003**	0.003
	[0.001]	[0.001]	[0.001]	[0.002]
Regular employment	-0.025***	0.012	-0.025***	0.021*
	[0.005]	[0.010]	[0.006]	[0.011]
Unemployed	0.013***	0.018***	0.015***	0.016***
	[0.003]	[0.004]	[0.003]	[0.004]
Out of labor force	0.017***	0.015*	0.020***	0.003
	[0.006]	[0.008]	[0.006]	[0.008]
Sample size (same for all rows)	66,117	43,052	62,394	40,803

C. High school or less educated

	All prefectures		Excluding the three most affected prefectures	
Dependent variable	Male	Female	Male	Female
Left the job held at the time of	0.015***	0.041***	0.010***	0.033***
the earthquake	[0.003]	[0.006]	[0.003]	[0.006]
Relocated to other prefectures	0.006***	0.001	0.006***	0.002
	[0.002]	[0.001]	[0.002]	[0.002]
Regular employment	-0.016**	-0.004	-0.011	0.007
	[0.007]	[0.009]	[0.007]	[0.007]
Unemployed	0.006***	0.014***	0.006***	0.012***
	[0.001]	[0.003]	[0.001]	[0.003]
Out of labor force	0.004**	0.012***	0.004***	0.010***
	[0.001]	[0.002]	[0.001]	[0.002]
Sample size (same for all rows)	158,343	115,071	147,965	107,948

Appendix Table A5: Replication of Table 3 (IV) with subsamples

A. Youth (age<=35 at the time of earthquake)

	All prefectures		Excluding the three most affected prefectures	
Dependent variable	Male	Female	Male	Female
Left the job held at the time of	0.257**	0.138*	0.290	0.072
the earthquake	[0.120]	[0.077]	[0.204]	[0.122]
Relocated to other prefectures	-0.012	0.000	-0.15	0.023
	[0.060]	[0.031]	[0.127]	[0.047]
Regular employment	0.024	-0.209**	-0.027	-0.224
	[0.125]	[0.096]	[0.239]	[0.160]
Unemployed	0.003	-0.004	0.031	-0.039
	[0.060]	[0.045]	[0.100]	[0.067]
Out of labor force	-0.02	0.083**	-0.027	0.103*
	[0.031]	[0.039]	[0.060]	[0.060]
Sample size (same for all rows)	59,511	48,108	56,194	45,477

B. Elderly (age>=60 at the time of earthquake)

	All prefectures		Excluding the three most affected prefectures	
Dependent variable	Male	Female	Male	Female
Left the job held at the time of	-0.073	-0.017	-0.343	-0.132
the earthquake	[0.166]	[0.101]	[0.247]	[0.136]
Relocated to other prefectures	0.053	0.011	-0.019	-0.035
	[0.131]	[0.110]	[0.321]	[0.237]
Regular employment	-0.041	-0.027	-0.215	-0.046
	[0.055]	[0.020]	[0.168]	[0.030]
Unemployed	-0.14	0.013	-0.197	-0.064
	[0.092]	[0.062]	[0.177]	[0.072]
Out of labor force	0	0.006	0.007	0.03
	[0.013]	[0.013]	[0.037]	[0.024]
Sample size (same for all rows)	66,117	43,052	62,394	40,803

C. High school or less educated

	All prefectures		Excluding the three most affected prefectures	
Dependent variable	Male	Female	Male	Female
Left the job held at the time of	-0.013	0.006	-0.052	-0.076
the earthquake	[0.045]	[0.046]	[0.054]	[0.056]
Relocated to other prefectures	0.025	-0.003	0.029	0.006
	[0.019]	[0.013]	[0.024]	[0.021]
Regular employment	0.225	0.146*	0.348	0.141
	[0.141]	[0.085]	[0.304]	[0.141]
Unemployed	-0.022	-0.023	-0.06	-0.037
	[0.025]	[0.020]	[0.048]	[0.035]
Out of labor force	-0.047*	0	-0.063*	-0.03
	[0.025]	[0.028]	[0.036]	[0.032]
Sample size (same for all rows)	158,343	115,071	147,965	107,948