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# The effects of supply chain disruptions caused by the Great East Japan Earthquake on workers

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## ABSTRACT

The Great East Japan Earthquake affected not only local workers employed by establishments that were directly damaged, but also those of their trading partners through supply chain disruptions. I estimate the effect of such indirect shocks to workers on their job separation, inter-industry mobility, geographical relocation, and employment status in the following years. I find that such shocks increased job separation in the study period. This increased job separation did not increase inter-industry mobility, but rather induced relocation to other prefectures. The effect on employment status was mixed: although the self-reported indicator of being affected by the earthquake is significantly correlated with negative outcomes such as high unemployment, the proxy for the production decline at the prefecture-industry level is uncorrelated with employment status. This result implies that people who faced a negative employment shock may have attributed it to the exogenous event, which may cause substantial bias in the self-reported data on the effect of disasters.

## 1. Introduction

The Great East Japan Earthquake on March 11, 2011 and subsequent tsunami destroyed many buildings and resulted in a 15% reduction in industrial output in the following months.<sup>1</sup> Although the direct damage was concentrated on the east coast of the Tohoku and Kanto regions, businesses in other areas of Japan were also affected through supply chain disruptions. For example, the disrupted supply of parts and components from damaged firms forced automobile makers such as Toyota Motor Company to cut their production in other areas<sup>2</sup> by 32.7% from March to June 2011 (Tokui et al., 2015). This production decline led to a substantial reduction in labor demand, at least in the short run. Then, how did workers respond to such labor demand shocks?

During the months following the earthquake, the mass media reported the growing concern of the public about the widespread

negative effects on employment, especially for non-regular workers, caused by such supply chain disruptions.<sup>3</sup> However, there is no clear evidence of the existence of such indirect effects on employment. On the one hand, studies of 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 forced to evacuate (Genda, 2014).<sup>4</sup> On the other hand, many studies document the indirect effect through supply chain disruptions on output (Okuyama et al., 2012; Cavalho et al., 2014; Tokui et al., 2015; Dekle et al., 2016), but ignore the effect on employment.<sup>5</sup>

This study aims to bridge this gap in the literature by examining the effect of the labor demand shocks caused by the Great East Japan Earthquake on workers' job separation, inter-industry and geographical mobility, and employment status in the following year. In particular, I focus on the indirect shocks caused by supply chain disruptions on workers who lived in prefectures that were not directly damaged by the

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<sup>1</sup> See the Industrial Production Index published by the Ministry of Economy, Trade and Industry.

<sup>2</sup> Prefectures other than most damaged four (Iwate, Miyagi, Fukushima, and Ibaraki).

<sup>3</sup> *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>).

<sup>4</sup> Genda (2014) examines which people tend to report that their employment was affected by the earthquake. In this way, 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 young people are more likely to report that their jobs were affected by the earthquake, whereas college-educated and regular employees are less likely to do so.

<sup>5</sup> The only exception of which I am aware is the research note by Nakano (2011). He estimates the impact of the decline in production on employment in nine regions of Japan, using the inter-regional input-output (I-O) table. However, as he acknowledges, his estimates are based on preliminary data that came available two months after the earthquake. Probably because of errors in these preliminary sources, his estimate of the nationwide loss of employment is much larger than the actual change in employment reported in other studies published later (Higuchi et al., 2012; Ohta, 2014).

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tsunami. Employment Status Survey (ESS) 2012 provides self-reported data on the repercussions of the Great East Japan Earthquake on the job held at that time.<sup>6</sup> About 5.5% of workers experienced changes such as temporary suspension, shorter working hours, and lower earnings, even in those areas not directly damaged by the tsunami. However, such self-reported data may be biased if some workers attribute the negative shocks actually caused by other factors to the earthquake. To mitigate this problem, I calculate the upper bound of the production decline at the industry-prefecture level based on the inter-prefecture I-O table and estimate its effect on individual workers' outcomes.

I find that the temporary decline in labor demand caused by supply chain disruptions induced workers to quit their jobs. Except for regular employees who experienced temporary suspension, the job separation hazard is positively correlated with both indicators for the self-reported repercussions and the estimated upper bound of the production decline at the industry-prefecture level.

Then, where did the workers who left their jobs go? Did they move to industries or prefectures that were less affected or did they ultimately suffer from unemployment? To answer this question, I examine industry and prefecture mobility and find that increased job separation did not lead to higher inter-industry mobility, but rather induced moves to other prefectures.

The effects on employment status in October 2012, 18 months after the earthquake, are mixed. People who answered that their job was affected by the earthquake are less likely to be employed or in regular employment and more likely to be unemployed or out of the labor force. By contrast, the estimated upper bound for the production decline at the prefecture-industry level is uncorrelated with employment status. This result implies that the self-reported data may be biased, because workers or their employers who faced a negative shock attributed it to the earthquake, even if this was not the true cause.

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. ESS 2012 and self-reported data of the repercussions to the job held at the time of the earthquake

The ESS is a cross-sectional household survey conducted by the Statistics Bureau of Japan every five years. The survey covers about 1,000,000 individuals above age 15 in about 470,000 households randomly drawn from all residents in Japan.<sup>7</sup> The sample is designed to be representative at the municipality level, using appropriate weights assigned to each individual or household.

The ESS asks questions about employment status and, if employed, the job characteristics and earnings of each household member above age 15 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 ESS conducted in October 2012 asked whether and how individuals were affected by the Great East Japan Earthquake.

By using the year and month in which (i) each individual started his

<sup>6</sup> As I explain in Section 2.1, the question asks about the repercussions from both the direct physical damage and supply chain disruptions. However, very few workers in my sample should have been affected by the direct physical damage since I exclude workers who lived in the prefectures hit by the tsunami.

<sup>7</sup> Strictly speaking, the following people are excluded: foreign diplomatic corps or consular staff (including their suite and their family members), foreign military personnel or civilians (including their family members), persons dwelling in camps or ships of the Self-Defense Forces, persons serving sentences in prisons or detention houses, and inmates of reformatory institutions or women's guidance homes.

or her current job and (ii) he or she quit his or her 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, the year and month of the move and the prefecture of the previous residence. By using these variables, the prefecture of residence at the time of the earthquake is identified. Individuals with missing information and those who were not employed at the time of the earthquake are dropped from the sample. Furthermore, I limit the sample to people aged 20–70 on the survey date. The Appendix describes this data construction process in detail.

Furthermore, I exclude people who lived in prefectures that were directly damaged by the tsunami, even though such residents are thought to be affected more than those in other prefectures for two reasons. First, I focus on the effect through supply chain disruptions, whereas people in these prefectures may have been forced to change jobs because of direct damage to their employers or families. Second, existing studies have already focused on directly damaged prefectures. Hence, the following six prefectures are dropped: Aomori, Iwate, Miyagi, Fukushima, Ibaraki, and Chiba.<sup>8</sup>

The question about the effect of the Great East Japan Earthquake on employment is “Was your main job at that time affected by damage to your workplace?” The respondent chooses one of the following answers: (1) not affected, (2) temporarily suspended, (3) lost job permanently, (4) affected in other ways (shorter working hours, change in shifts, wage cuts, etc.), and (5) not employed at that time. The survey instruction clearly states that “damage” includes damage to other branches of the company and supply chain disruptions.<sup>9</sup> Although damage also includes the direct physical damage from the earthquake, such direct damage was rare in areas other than the prefectures directly hit by the tsunami.<sup>10</sup>

Table 1 presents the summary statistics. Very few workers answered that they lost their jobs permanently because of the earthquake. By contrast, 1.6% of workers experienced temporary suspension and 3.8% were affected in other ways. A non-negligible number of workers were affected by supply chain disruptions, even in those areas not directly hit by the tsunami, although the immediate impact on employment was limited.

I use these variables as a proxy for the labor demand shocks their employers faced right after the earthquake, presumably because of supply chain disruptions. There are two possible channels through which temporary suspension or other changes (e.g., shift changes) can induce workers to leave their jobs in the future. First, these changes may make workers unsatisfied with their jobs, thereby inducing voluntary separation. In particular, reduced working hours lead to a substantial earnings loss, especially for non-regular workers on hourly wage contracts. Second, assuming that these changes were caused by a reduction in production, this may reduce the firm's profit and lead to employment adjustments with some time lag.

An important limitation of the self-reported data is potential bias from workers' or employers' self-justification. Some workers who

<sup>8</sup> Although human damage was concentrated on Iwate, Miyagi, and Fukushima, coastal buildings in the other three prefectures also suffered substantial damage. The ratios of workers who worked in establishments in areas affected by the tsunami are as follows: 6% in Aomori, 12% in Iwate, 20% in Miyagi, 7% in Fukushima, 5% in Ibaraki, and 1% in Chiba.

<sup>9</sup> It also states that “damage” does not include any effects of limits on electricity usage or planned outages. Nonetheless, some respondents may have ignored the instruction. In particular, many workers were forced to change their shifts because the government asked large manufacturing companies to avoid operations in peak-time, and some of them may have answered (4). Furthermore, “damage” does not include decline in sales due to depression among consumers or any negative rumors from fear of radiation contamination.

<sup>10</sup> According to the survey instruction, in addition to the direct damage to the workplace and indirect effect through supply chain disruptions, damage also includes the direct damage on the individual's family and home and evacuation order because of the nuclear power plant accident. This ambiguity in the source of damage is another reason why I exclude people who lived in the prefectures hit by the tsunami.

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