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Well-being effects of a major natural disaster: The case of Fukushima

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ABSTRACT

Based on a quasi-experimental difference-in-differences approach, we use panel data for 5979 individuals interviewed in Japan before and after the tsunami and nuclear accident at Fukushima to analyze the effects of the combined disaster on people's subjective well-being. To conduct our analysis, we use Geographical Information Systems to merge the subjective well-being data with information on respondents' distance from the Fukushima Dai-ichi nuclear power plant, their proximity to nuclear power stations in general, and the spatial distribution of radioactive fallout after the accident. Our main findings are as follows: (1) After the disaster, people living in a place affected by the tsunami or close to the Fukushima Dai-ichi power plant experienced a drop in life happiness, while the effects declined with distance to the place of the disaster. (2) No change in subjective well-being is detectable in people living close to nuclear facilities in general. (3) In contrast to happiness with life after the disaster, no effect on people's happiness with their entire life can be found among those affected by the disaster. (4) The drop in life happiness in municipalities affected by the tsunami is equivalent to 72% of annual income and reaches 240% for those living in close distance to the Fukushima Dai-ichi power plant ($\leq$150 km).

1. Introduction

On 11 March 2011, following a major earthquake off the Pacific coast of Japan, a tsunami disabled the power supply and cooling systems of three reactors of the Fukushima Dai-ichi power plant, causing a major nuclear accident. The accident triggered substantial releases of radioactive material and resulted in one of the worst nuclear disasters ever, second only to the Chernobyl disaster in 1986. The earthquake and tsunami caused nearly 16,000 deaths, over 1.2 million destroyed or damaged buildings, and temporary evacuation from their homes for over 380,000 people. The combined event (earthquake, tsunami, nuclear accident) also disrupted water supply, power distribution, and train, highway, and air transport systems in extensive areas of eastern Japan.

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The disaster at Fukushima may have impacted on subjective well-being (SWB) in a variety of ways, some of which involve physical consequences of the disaster whereas others refer to psychological mechanisms.[1] The physical consequences of the disaster may have led to income losses, job losses or health impairments. In addition, it may have caused psychological costs in terms of fear, anxiety or mental distress related to fatalities, injuries or radioactive contamination. Some of those psychological costs need not be restricted to persons directly affected by the event. Due to media coverage, they may spill over and cause distress in other, more distant places. Notably in the case of a major nuclear accident, people may become worried about nuclear power in general, especially if they live close to nuclear facilities themselves. Depending on how serious consequences were, they may have implied fundamental changes in how people evaluate happiness with their entire life up to the present.

Based on a quasi-experimental difference-in-differences (DD) approach, we use nation-wide panel data for 5979 individuals interviewed in Japan before and after the disaster to analyze its impact on people's SWB, specified as happiness with life.[2] More specifically, we study the following research questions: (1) In which ways, if any, has the Fukushima disaster affected the happiness of those affected? (2) Has the nuclear accident at Fukushima reduced the happiness of people living close to nuclear power stations in general? (3) Has the disaster affected not just people's happiness with their life after the event, but happiness with their entire life? (4) What are the monetary equivalents of the disaster's SWB effects?

To address those questions, we use several indicators that correspond to various dimensions of the disaster and of its consequences. In particular, we use measures of the distance from or proximity to the place of the disaster to capture the idea that some of its effects may decay with distance, in particular effects related to the breakdown of electricity supply and other infrastructures and to radioactivity. To capture effects of the earthquake and tsunami more specifically, we use measures of fatalities and injured persons and of destroyed or damaged buildings by geographic unit. Radioactivity-related effects are captured by the level of radioactive substances in different areas. To explore the hypothesis that the nuclear accident may have spurred people's concern over nuclear power more generally we use indicators of the presence and density of nuclear plants near the places where people live. Finally, we use an alternative measure of SWB to explore the possibility that the disaster may have affected not just people's happiness with their life after the disaster, but happiness with their whole life up to the present.

Our identification strategy is to use those indicators as measures of (the degree of) treatment by the different dimensions of the disaster and to study whether people's happiness with their lives has changed after the disaster depending on the nature and extent of treatment, yielding a multi-dimensional DD design. By running happiness regressions that control for income, unemployment and health, and regressions that do not control for those factors, we are able to differentiate between mechanisms that involve the physical consequences of the disaster and psychological mechanisms (fear, anxiety, mental distress) that may affect happiness independent of those variables.

Our paper is the first to find an effect of a natural disaster on SWB within a spatial quasi-experimental DD framework and to estimate its implicit monetary value. In connection with nuclear accidents, Almond et al. (2009) have investigated the impacts of the Chernobyl disaster on health and school outcomes, but not its effect on SWB and the monetary equivalent. Berger (2010) and Goebel et al. (2013) found an increase in German citizens' concern about the environment after Chernobyl and Fukushima, respectively, but no change in SWB. Focusing on the Fukushima disaster, Yamane et al. (2013) analyze its impact on local property values. Ohtake and Yamada (2013) use data elicited after the disaster to explore the spatial and temporal SWB pattern post-Fukushima but are unable to analyze the difference in SWB before and after the event.[3] Other SWB studies of single disasters are Kimball et al. (2006) and Metcalfe et al. (2011). The first of these analyzes the unhappiness of Americans after hurricane Katrina, while the other studies mental distress in British citizens following the 9/11 attacks on the World Trade Center. Instead of addressing particular events, Luechinger and Raschky (2009) and Carroll et al. (2009) use a correlational design to study the relationship between floods and droughts, respectively, and SWB. We extend the literature on natural disasters and SWB by providing evidence of an effect of the former on the latter by (i) applying a quasi-experimental DD approach and (ii) explicitly taking account of the spatial dimension. To our knowledge, no SWB study of a natural disaster featuring (i) and (ii) has established such an effect as yet.

To conduct our analysis, we use Geographical Information Systems to merge SWB data with information on respondents' distance from the Fukushima Dai-ichi nuclear power plant and their proximity to nuclear power stations in general. We further use information on the spatial distribution of radioactive fallout after the accident and identify regions that were affected by the tsunami. Our SWB data come from the Keio Household Panel Survey (KHPS), 2011 and 2012. Our main measure of SWB is the response to a question asking individuals about their happiness with life in the previous year. Since the interviews in the KHPS were conducted in January of the respective year, the answers from the 2011 survey refer to the "pre-Fukushima" period while those from the 2012 survey refer to the "post-Fukushima" period. In addition to life happiness in the previous year, the respondents are also asked about happiness with their entire life. In our econometric analysis we

[1] We use the term disaster to denote the combined event (earthquake, tsunami, and nuclear accident).

[2] Among various measures of subjective well-being, the primary distinction is between cognitive life evaluations, derived from questions about how happy or satisfied people are with their lives, and emotional reports (Helliwell and Wang, 2012). The measures used in this paper refer to how happy people are with their lives, and we refer to them throughout the paper as 'happiness with life' ('happiness' for short).

[3] Keio University has published two books in Japanese containing a collection of papers based on KHPS data on SWB and the disaster (Seko et al., 2012, 2013). None of these papers discuss the disaster in terms of the spatial dimension.