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How do agricultural markets respond to radiation risk? Evidence from the 2011 disaster in Japan☆

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ABSTRACT

Since the explosion of the Fukushima Daiichi Nuclear Power Plant in March 2011, public anxiety surrounding the radioactive contamination of food and the environment has become widespread. This article examines how vegetable prices in the Tokyo Metropolitan Central Wholesale Market were affected in the wake of the nuclear accident. This study exploits the quasi-experimental condition generated by this accident to test market price changes using monthly panel data on the price of six types of fresh vegetables from each of the 47 prefectures in Japan. Our estimation results show that the prices of vegetables grown in Fukushima Prefecture decreased by 10–36% after the disaster compared with the counter-factual estimates in the absence of a perceived radiation risk. This effect has persisted even after radioactive detection tests showed negative results in subsequent years. The consumer behavior of avoiding vegetables from Fukushima and instead buying vegetables grown in other areas may explain the price gap.

1. Introduction

The Great East Japan Earthquake on March 11, 2011, the subsequent tsunami, and the resulting accident at the Tokyo Electric Power Company's Fukushima Daiichi Nuclear Power Plant (NPP) caused devastating socioeconomic damage to Eastern Japan. Soon after the nuclear power plant accident, public anxiety surrounding the radioactive contamination of food and the environment became widespread.

In this article, the prices of six types of fresh vegetables (asparagus, bean sprouts, broccoli, cucumbers, green beans and tomatoes) are used to examine how the actual pricing of agricultural produce in the wholesale market in Tokyo, which is the largest consumption center for agricultural produce from Eastern Japan, was affected in the wake of this nuclear accident. If urban consumers fear that food produced in or near Fukushima is more likely to contain radioactive materials and is thus more harmful to their health because of the potential of radiocesium/iodine intake causing internal exposure, they will avoid purchasing these products and will instead buy substitutes produced in areas distant from Fukushima. Since 2000, Japanese agricultural regulations have mandated that agricultural produce be labeled with the site of origin and that this information be made available to consumers. We use this information to assess the market's reaction to radiation risk under the shock of the Fukushima Daiichi NPP accident.

In addition to the practical importance of assessing the impact of this nuclear disaster (the largest in history in terms of scale) on agricultural markets, the use of agricultural price data makes a novel contribution to the hedonic environmental valuation literature by assessing urbanites' perceptions of environmental risks. Unlike

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houses, vegetables are transported from the site of origin and are delivered to consumer locations. This mobility allows us to assess urban consumers' risk perceptions (willingness to accept the risk) toward an environmental hazard that originates at a distant location. The large number of transactions in the urban consumption center as well as mobility allow their hedonic price functions to follow those of differentiated products (Epple, 1987; Rosen, 1974). In addition, the perishable nature of fresh vegetables allows our analysis to focus on short-term risk perceptions, whereas house prices are subject to expectations in response to future environmental changes (Gayer and Viscusi, 2002; Kiel and McClain, 1995; Tajima, 2003).

In this study, we analyze monthly panel data on the mean price (monthly average of auction prices per kilogram) of six types of vegetables traded in the Tokyo Metropolitan Central Wholesale Market from January 2006 to February 2015. Monthly price data are available at the level of 47 Japanese prefectures, allowing us to estimate the marginal effect of the perceived radiation risk on the market prices before and after the nuclear accident. The monthly panel data also enable us to exploit the quasi-experimental condition generated by the nuclear accident. The estimation results show that having been grown in Fukushima Prefecture emerged as a new factor that decreased the value of vegetables traded in the Tokyo Wholesale Market by 10–36%. The wholesale prices of most vegetables traded in the Tokyo market were only slightly influenced by the distance between the prefectures where the vegetables were grown and the Fukushima Daiichi NPP.

The rest of the article is organized as follows. Section 2 reviews the hedonic studies of environmental hazards and food safety. Section 3 provides the background for this disastrous event. Section 4 presents our theoretical and econometric models and describes the data, and Section 5 summarizes the empirical results. Section 6 concludes and provides policy implications.

2. Literature

This study builds on the intersection between two distinct lines of research that use the hedonic pricing method: (1) studies that examined the impact of proximity to environmentally hazardous sites on local housing prices and (2) studies that measured the effects of health benefits or risks on the price of agricultural products. Recent studies that have aimed to measure the impact of the Fukushima nuclear accident are also reviewed with respect to these lines of research.

Urban and environmental economists have long used the hedonic pricing method to estimate the risk perception associated with environmental hazards. The majority of the literature uses local housing transaction data as well as repeated sales data to single out the effects of risks that originate from hazardous waste sites (Gayer and Viscusi, 2002; Greenstone and Gallagher, 2008; Kiel, 1995; Kiel and McClain, 1995; Kohlhase, 1991). Naoi et al. (2009) analyzed the rents and owner-provided values of houses in a household panel survey to show that the risk perception toward earthquakes experienced an upward change after major earthquakes. Other studies analyzing the impact of spent nuclear waste used their transportation routes (rail tracks) and proximity to assess their impacts on local housing prices (Gawande and Jenkins-Smith, 2001; Gawande et al., 2013). House prices were used because they are fixed in specific locations, as is the source of environmental hazards, and a clear relationship can be established between them through their geographical proximity. These relationships are represented in econometric models as a distance or dummy variable to indicate the likelihood of environmental risk in a particular area.

Recent studies have contributed to the aforementioned literature by addressing the impacts of the Fukushima nuclear disaster. The immediate impacts of radioactive contamination on appraised land prices (Yamane et al., 2013) and market transaction land prices (Kawaguchi and Yukutake, 2014) were estimated using a hedonic pricing framework. These findings demonstrate that the actual contamination level reduced land prices significantly.

Researchers outside of Japan tested whether the Fukushima nuclear disaster increased consumers' risk perceptions regarding nuclear power plants. Using a difference-in-difference hedonic approach, Fink and Stratmann (2015) did not find a discount in house prices in areas located near nuclear power plants in the United States. By contrast, Boes et al. (2015) found a 2.3% discount in advertised apartment rents near nuclear power plants in Switzerland after the Fukushima accident. Zhu et al. (2015) found a short-term (one month after the Fukushima disaster) but significant reduction in land transaction prices within 40 km of active nuclear plants in China.

Food and agricultural economists have applied the hedonic pricing method to estimate the effects of various characteristics of vegetables, such as size, color, ripeness, and taste, on their retail prices (Huang and Lin, 2007). This technique has also been used to estimate the loss of value associated with potential health risks or the price premium associated with avoiding pesticide risks by purchasing organic foods (Estes and Smith, 1996; Lin et al., 2008; Maguire et al., 2004; Thompson and Kidwell, 1998), the reduced price of genetically modified organisms (Loureiro and Hine, 2004), and the reduced price of milk produced from cloned cows (Brooks and Lusk, 2010). Asche and Guillen (2012) addressed the negative effects of certain sites of origin on the market prices of frozen fish (Spanish hake) and attributed these effects to consumers' general environmental concerns that could not be ascribed to a particular hazard source. Most of this literature uses individual purchases at retail stores as the unit of analysis based on field surveys or the use of scanner data. These trade variables are complemented by identifiers of the purchaser's characteristics (typically age, gender, income, education and household attributes, for instance, if they live with young children) to analyze the role of these attributes in purchasing decisions. Our empirical method is based on the literature described above. However, the use of monthly prefecture-level data on wholesale price and quantity requires a unique approach, such as the use of a panel estimation model, to address the aggregate nature of our data.

In the wake of the Fukushima accident, a significant number of Japanese scholars addressed the impacts of radioactive food risks and the public anxiety associated with these risks. Ujiie (2013) analyzed consecutive questionnaire surveys that were conducted every four months after the earthquake to estimate consumers' willingness to accept (WTA) or buy produce (spinach and milk) from Fukushima and Ibaraki Prefectures.[1] He then estimated the contribution of "health risk due to radioactive contamination" and the "origin of the food." The results suggested that consumers' aversion to agricultural food due to fear of contamination remained strong two years after the nuclear accident. The level of aversion was higher for respondents living in Western Japan (Osaka) compared with those living in Eastern Japan (Tokyo). In addition, Ujiie (2014) suggested that the demand for food produced in "distant" areas was increasing among major retailers.

Other researchers addressed these issues using stated-preference economic studies, such as choice experiments (Kuriyama, 2012), conjoint surveys, and other forms of consumer surveys. Most studies obtained consistent results that suggested the prevalence of a lower willingness to pay for fresh food produced in the disaster-affected areas in the wake of the nuclear disaster. Yoshino (2013) examined actual market price data to estimate losses due to price reduction after the nuclear incident. He estimated the typical yearly price gaps in the years prior to the nuclear accident and compared the result with the actual price difference after the accident. Although this approach is suitable for estimating the aggregate welfare loss, it does not allow

[1] Ibaraki Prefecture is adjacent to Fukushima Prefecture to the south.