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Abstract

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Collective reputation and externalities in agriculture: Lessons from Fukushima nuclear accident[*]

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Abstract

Negative externalities undermine collective reputation. Despite recent empirical attention to the impact of collective reputation on economic activities, very little is known about the effects of the reputational loss on input decision-making of suppliers. We document the reputational loss in the context of a sensational issue that affected the Japanese agrarian sector in 2011 due to the Fukushima Nuclear Accident. Using farm household-level agricultural census and a difference-in-differences approach, we identify substantial reputational impacts on non-contaminated areas within Fukushima prefecture. Our findings suggest that the reputational loss reduces the adoption of high-value-added agricultural practices, such as eco-friendly farming, even when product safety is assured. Finally, the results indicate that the land rental market plays an adaptive role in response to the Fukushima nuclear accident.

Keywords: Collective reputation, Negative externality, Natural disaster, Supply shock, Land market

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1. Introduction

In commodity markets, the reputation of goods, branding in other words, works as a signal to consumers so that suppliers obtain additional rent from the reputation. Collective reputation — defined as the aggregation of individual reputations (Tirole, 1996) — is particularly influential in agriculture, where geographical indicators strongly affect competitive equilibrium (Curzi & Huysmans, 2022; Mao & Görg, 2024; Takayama, Norito, et al., 2021). The collective reputation gives incentives to farmers to improve the quality of their products to have larger reputations and greater gains from them. However, reputational crises caused by external shocks can disrupt value chains and influence consumer behaviors such as willingness to pay for the agricultural products.

Environmental concerns impose an externality on the collective reputation of products. Indeed, a negative externality is one of the drivers of reputational loss (Bai et al., 2022). Pollution scandals and radioactive contamination, for instance, have far-reaching consequences for collective reputation, particularly in sectors dependent on regional branding (Bachmann et al., 2023; Tajima et al., 2016). In agriculture, reputational crises impose substantial costs on producers, who may face reduced bargaining power in the market or lower prices despite maintaining high product quality. While extensive research has documented the benefits of collective reputation for producers, limited attention has been paid to the consequences of reputational loss, especially its impact on input decision-making, such as land use and the adoption of high-value-added practices.

Despite growing interest in collective reputation across various industries—including vehicles, software, garments, and food (Bachmann et al., 2023; Bai et al., 2022; Banerjee & Duflo, 2000; Gergaud et al., 2017; Ito & Kuriyama, 2017; G. Z. Jin & Leslie, 2009; Koenig & Poncet, 2022; Matsumoto & Hoang, 2020)—empirical studies on how reputational loss affects producers' input decision-making remain scarce. This gap stems from both limited data availability and the challenge of identifying causal effects. Understanding these effects is crucial because reputational shocks can undermine producers' incentives to invest, with long-term implications for productivity and resilience to reputational crises.

This study addresses these gaps by leveraging the Fukushima nuclear accident of 2011 as an exogenous shock on an agrarian market. The accident triggered widespread reputational loss to agricultural products from Fukushima prefecture, even in areas unaffected by contamination. Using a household-level agricultural census dataset and a difference-in-differences (DID) approach, we estimate the causal impact of reputational loss on farmers' decision-making. Our analysis focuses on agricultural output, land use, and the adoption of eco-friendly farming practices.

Our contributions are threefold. First, we provide novel evidence of how negative externalities and reputational loss influence farmers' input decision-making, extending the literature that has focused on output effects and consumer preferences. Second, we demonstrate that information friction exacerbates reputational loss, discouraging investments in high-value-added agricultural practices. It is consistent with theoretical understanding but provides one of the first empirical evidence showing the loss of reputational loss reduces the farm investment to improve the quality of goods. Third, we show how market mechanisms, particularly land rental markets, play an adaptive role in mitigating the economic impact of reputational crises. These insights have broad implications for understanding the intersection of reputational crises, environmental externalities, and agricultural policies.

The remainder of the paper is organized as follows. Section 2 outlines the background of the Japanese rice market and the Fukushima nuclear accident. Section 3 describes the data and variables, while Section 4 details the econometric framework and results. Section 5 concludes with policy implications and directions for future research.

2. Background on the rice market in Japan and the Fukushima nuclear accident

2.1. Rice production in Japan

Rice is the most consumed stable crop in Japan, and northeast part of Japan is a main area of rice production. In Japan, one of the most famous rice brands is *Koshihikari*. *Koshihikari* has various local brands across the country. For example, if *Koshihikari* is cultivated in a part of Niigata prefecture, it is considered as “*Uonuma Koshihikari*” while it is called as “*Aizu*

Koshihikari" if it is cultivated in the western part of Fukushima prefecture. In terms of the amount of rice production, Niigata prefecture, located next to Fukushima, is the most producing prefecture in Japan, and Fukushima is placed at the 4th place.

During the 2000s, the gap in rice production between Fukushima Prefecture and Niigata Prefecture gradually narrowed. However, after 2011, this gap widened substantially (Figure A1). It indicates that agriculture in Fukushima in 2011 was affected by many ways of such as the earthquake, tsunami, and the Fukushima nuclear accident. On account of these two aspects, it is reasonable to choose farms in Fukushima prefecture and Niigata prefecture as a sample to determine the reputational quantitative loss by the accident in Japanese agriculture.

2.2. **Fukushima nuclear accident**

On March 11, 2011, the Great East Japan Earthquake struck Tohoku region, a northeastern part of Japan, causing a tsunami that hit the Fukushima nuclear power plant and resulted in a meltdown of the reactors. This incident led to a significant release of radioactive material, raising nationwide concerns about nuclear safety. It is historically the worst nuclear incident since the Chernobyl disaster in 1986. The government has issued an indoor evacuation directive for the area within 20 to 30 kilometers of the nuclear power plant. The middle and coastal areas of Fukushima prefecture, which are at most 75 kilometers away from the nuclear power plant experienced contamination. However, the western part remained unaffected such as the Aizu area, which is located more than 100 kilometers away from the nuclear power plant. After the accident, mass media reported and provoked fear about the radioactive contamination in Fukushima prefecture, resulting in reputational damage for the western part of Fukushima prefecture. As Saak (2012) states that collective reputation is greater when public information is disseminated more rapidly, the price of agricultural products, livestock, and fish in Fukushima prefecture declined. After the accident, 55 countries have banned importing agricultural products and seafood in Fukushima prefecture. Despite government inspections confirming the safety of rice shipments from the western part after the accident, concerns persisted about the potential contamination of agricultural products in that region. Aside from the agricultural sector, the accident affects many aspects of our societies, such as residential location choice, residential land markets, well-being, preferences on the energy mix, and mortality rate (He & Tanaka, 2023; Horie & Managi, 2017, 2017; Kawaguchi & Yukutake, 2017; Rehdanz et al., 2015)

Figure A2 is a distribution map of areas contaminated by radioactive materials in Fukushima and neighboring six prefectures in 2012. Figure A2 shows that the western side of Fukushima prefecture was not contaminated by radioactive materials while the central and coastal side of Fukushima were highly contaminated. Some parts of Gunma prefecture which is south of Fukushima and Miyagi prefecture which is north of Fukushima were also contaminated. Since the Aizu area of Fukushima was not physically affected by radioactive materials, we assume that it would be affected by only reputational loss by the Fukushima nuclear accident.

3. Data

Our data are drawn from the Census of Agriculture and Forestry, which was archived by the Digital Archive of Statistics on Agriculture, Forestry and Fisheries, Kyoto University, based on the original data provided by the Ministry of Agriculture, Foresty and Fisheries (MAFF). This census has been conducted every five years since 1950 for all farms to measure actual agricultural conditions in Japan. The census contains information on agricultural input resources at the farm level. Due to limited data availability, we use data in 1995, 2000, 2005, 2010, and 2015. The census was processed as a household-level panel structure. We restrict the sample to farm households in four municipalities—Hinoemata Village, Tadami Town, Kaneyama Town, and Nishi Aizu Town in Fukushima Prefecture—as treatment groups that are expected to be affected by collective reputation and the accident following the Great East Japan Earthquake. Other farm households in Aga Town, Sanjo City, and Uonuma City in Niigata Prefecture are considered control groups that are not expected to be affected by collective reputation and the accident. Figure 1 shows the geographical boundaries between Fukushima and Niigata prefecture and the boundaries of rural communities. The communities falling inside the contiguous towns formed by the boundary of the prefectures contribute to the treatment groups.

The dependent variables are several measurements of agricultural production, input decisions, and practices. First, we use the rice revenue as an output of farm households. Due to the data availability, the rice revenue data is not continuous but categorical. Therefore, we convert the categorical variable into the medium value. For example, if a category of ¥150,000 to ¥500,000 was applied, it was considered to have a sales value of ¥325,000, and if ¥3 to ¥5 million, it was considered to have a sales value of ¥4 million.[1] Second, we measure some input variables, which are hectares of owned paddy fields, cultivated paddy fields, total farmland rent out, and paddy field rent out. Third, we use dummy variables of adoption of eco-friendly agricultural practices such as non-pesticide farming, manure farming, and compost soil farming.

Table 1 presents the summary statistics of the data used in this study, as well as the pre-trend balance test for the Fukushima nuclear accident. On average, farm households in Niigata prefecture earn more from rice farming and cultivate rice on larger paddy fields than those in Fukushima prefecture. Additionally, farmers in Fukushima prefecture are more likely to rent out their paddy fields compared to those in Niigata prefecture. In terms of environmentally friendly farming practices, farmers in Niigata prefecture are more likely to use manure and

[1] This categorical variable has up to 15 levels. If there are no sales, the farmer's sales are considered to be 0 yen. If less than 150,000 yen, it is considered 75,000 yen. If sales are between 500,000 and 1,000,000 yen, they are considered to be 750,000 yen. Sales between 2 and 3 million yen are considered to be 2.5 million yen. Sales between 3 and 5 million yen are considered to be 4 million yen. 5~7 million yen shall be considered as 6 million yen. 7 to 10 million yen is considered 8.5 million yen. If the value is between 10~15 million yen, it is considered as 12.5 million yen. In case of 15~20 million yen, it is regarded as 17.5 million yen. In the case of 20~30 million yen, it is regarded as 25 million yen. In the case of 30~50 million yen, it is considered 40 million yen. In the case of 50~100 million yen, 75 million yen shall be considered. For the category of 100 million yen or more, it shall be deemed as 10 million yen.

avoid pesticides, while farmers in Fukushima prefecture are more likely to adopt composting, even before the Fukushima nuclear accident. With the exception of a variable related to having inheritors, the characteristics of the treatment groups are systematically different from those of the control groups. Overall, Table 1 shows that a scale of rice farming in Niigata prefecture is larger than the one in Fukushima prefecture as Niigata prefecture is the largest rice producing prefectures in Japan.

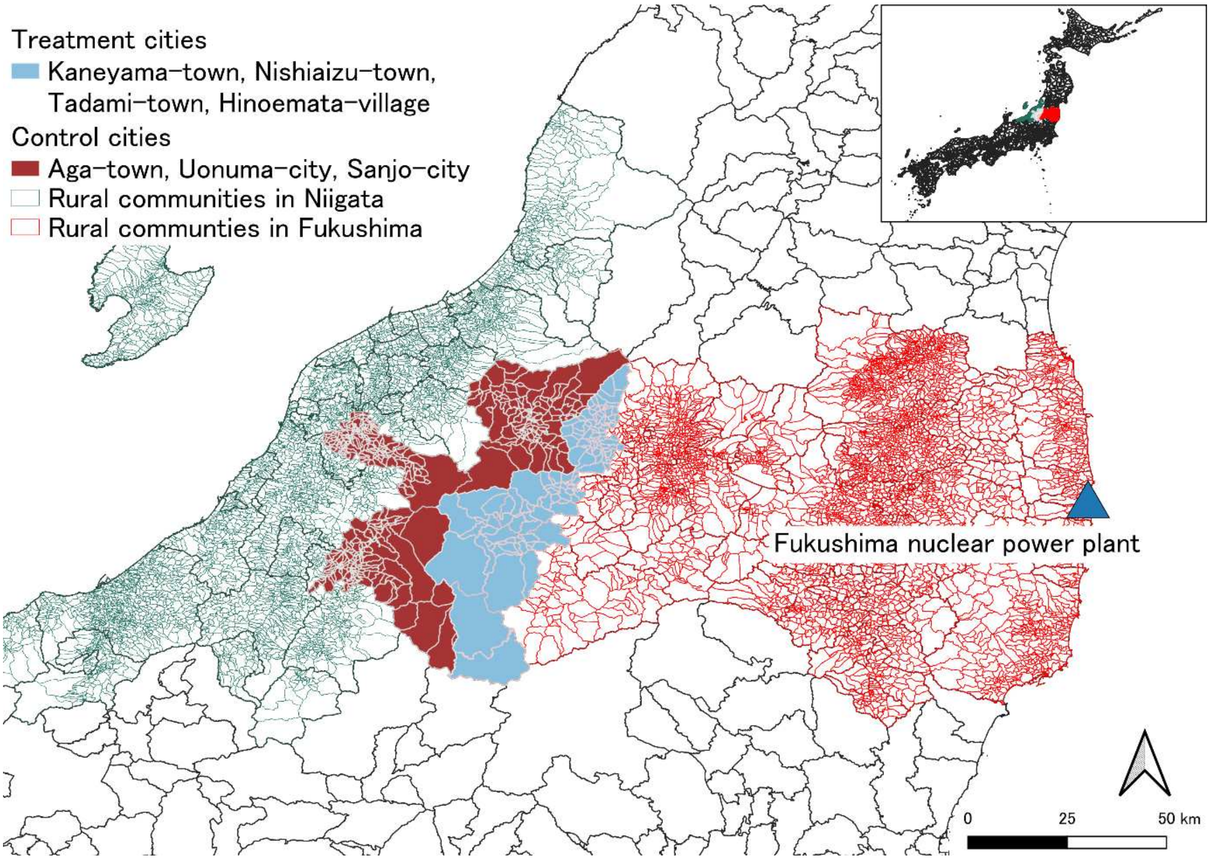

Figure 1 Geographical relationship between Fukushima and Niigata prefectures.

Source: Authors' design.

Table 1 Descriptive statistics from 1995-2010: Pre-trend of Fukushima nuclear accident

Variables	Fukushima			Niigata			Balance
	N	Mean	SD	N	Mean	SD	Dif
Rice revenue (million yen)	5,621	110.51	257.26	29,223	200.98	499.88	-90.47***
Cultivated paddy field (a)	5,621	90.79	131.54	29,223	117.90	114.86	-27.11***
Total field rent out (a)	5,621	6.67	20.70	29,223	5.42	21.33	1.25***
Paddy field rent out (a)	5,621	4.77	17.12	29,223	3.95	17.71	0.82***
Non-pesticide (=1 if yes, 0 otherwise)	3,850	0.26	0.44	20,668	0.33	0.47	-0.07***
Adoption of manure (=1 if yes, 0 otherwise)	3,850	0.22	0.41	20,668	0.29	0.45	-0.07***
Adoption of compost soil (=1 if yes, 0 otherwise)	3,850	0.22	0.42	20,668	0.20	0.40	0.02***
Age of HH head	5,621	60.79	11.49	29,223	58.82	11.36	1.97***
Male of HH head (=1 if yes, 0 otherwise)	5,621	0.95	0.22	29,223	0.98	0.15	-0.03***
Having inheritors (=1 if yes, 0 otherwise)	5,621	0.48	0.50	29,223	0.63	0.48	-0.15
Corporation Farm (=1 if yes, 0 otherwise)	5,621	0.00	0.03	29,223	0.00	0.03	0.00***
Household size (number of family members)	5,621	3.87	1.82	29,223	4.70	1.87	-0.83***
Full-time farmer (=1 if yes, 0 otherwise)	5,621	2.52	0.79	29,223	2.71	0.63	-0.18***
Selling to cooperative (=1 if yes, 0 otherwise)	2,284	0.65	0.48	12,594	0.83	0.38	-0.17***

Source: The Census of Agriculture and Forestry 1995, 2000, 2005, and 2010.

Note: Author calculation. *, **, and*** denote significance at the 10%, 5%, and 1% level, respectively. The unit of cultivated paddy field, total field rent out, and paddy field rent out is "*are*" expressed as "a" which is 100 m^2.

4. Conceptual and empirical framework

To analyze the effects of reputational damage on Japanese rice farmers following the Fukushima nuclear accident, we propose a conceptual framework with testable hypotheses. Our analysis builds on basic models where price is determined by collective reputation and farmers choose quality at a cost (Winfree, 2023; Winfree & McCluskey, 2005). Rice from Niigata and Fukushima prefectures traditionally commands a price premium due to its perceived superior quality compared to standard rice. This premium is influenced by collective reputation effects. The literature on collective reputation primarily assumes that price is determined by shared reputation while individual firms make quality decisions at a cost(Winfree, 2023). Within this framework, we examine how reputational loss affects farmers' input decisions related to quality investment. Given these assumptions, we can express an individual farmer's profit function as:

$$\pi_i = q_i p_i\left(k_i, R_j, Q\right) - q_i c(k_i) \tag{1}$$

where π_i is a farmer *i*'s profits, q_i is the farmer's quantity, p_i is the price, k_i represents quality for the farmer's product, R_j represents group *j*'s reputation (farmer *i* is a member of this group), Q is the total production in the market, and *c* is the cost of production[1]. The first order condition to maximize aggregate profits would be given by $\frac{\partial P_i}{\partial k_i} + \frac{\partial p_i}{\partial R_j} = \frac{\partial c}{\partial k_i}$.

[1] Following conventional theoretical studies (Winfree, 2023), we assume quantity (*Q*) is fixed for farmers, as our focus is on examining the effect of reputational loss on quality investment.

When collective reputations matter (Bachmann et al., 2023; Bai et al., 2022; Castriota & Delmastro, 2015; Y. Jin et al., 2023; Neeman et al., 2019; Tajima et al., 2016; Winfree & McCluskey, 2005), the partial derivative with respect to the reputation can be written as $\frac{\partial P_i}{\partial R_j} \geq 0$. When individual reputations $(\frac{\partial P_i}{\partial k_i} \geq 0)$ matter, marginal cost of the quality of agricultural products can be expressed by $\frac{\partial c}{\partial k_i} \geq 0$. In our setting, R_j decreases because of the Fukushima nuclear accident which induces a decline in rice price. Therefore, we observe underinvestment for farming (a decline in k_i).

This illustrates that, to the extent that there is a collective reputation $\frac{\partial P_i}{\partial R_j} > 0$, farmers will underinvest in the quality of the rice. It indicates that farmers incur the full costs of the quality decisions which are related to input decision-making. Other theoretical literature also argues that a collective reputation induces stronger incentives to invest in a brand and past bad collective behavior increases the probability of being stuck in a "bad reputation trap."(Castriota & Delmastro, 2015; Neeman et al., 2019). Thus, we hypothesize that the reputational loss by the Fukushima nuclear accident affects farmers' input decision-making such as farmland size and adoption of eco-friendly agriculture which may create individual reputations.

Following a standard DID regression specification, we estimate the following model to examine the reputational effects on farmers:

$$y_{it} = \gamma Accident_{pt} + \beta X_{it} + \alpha_i + \delta_t + \epsilon_{it} \quad (2)$$

where y_{it} is the outcome variables of household *i* in year *t* including the inverse hyperbolic sine (HIS) transformation of rice revenue, owned paddy field, cultivated paddy field, total field rent out, paddy field rent out, and dummy variables of adoption of no-pesticide, manure fertilizer, and compost soil farming. $Accident_{it}$ is an indicator variable whether a household *i* at year *t* indirectly experienced the Fukushima nuclear accident. X_{it} is a vector of covariates. α_i and δ_t are respectively household and year fixed effects. ϵ_{it} is an error term. The coefficient γ measures the reputational impact of the Fukushima nuclear accident. Furthermore, the model requires a parallel trend assumption to satisfy the common trends assumption. To test this assumption, we conduct an event study that exploits variation in the exposure to the Fukushima nuclear accident. Results from the event study can verify whether the outcome variables meet the parallel trend assumption and also considered as robustness checks.[2]

There are some concerns about the identification strategy[3]. First, we are concerned about supply chain disruption due to an earthquake and a tsunami in 2011. Based on the literature, such supply chain disruption would be diminished after six months of natural disasters (Barrot

[2] The graphical description of the event study analysis is shown in Appendix. The following regression is estimated for the event study analysis; $y_{it} = \sum_{l=-4,l\neq-1}^{1} \omega_l accident_{i,t-l} + \beta X_{it} + \alpha_i + \delta_t + \mu_{it}$ where $accident_{i,t-l}$ is an indicator variable for event time *l*, meaning that the accident took place *l* periods before this observation's calendar time. μ_{it} is an error term. The results of event studies are shown in Figure A3.

[3] Public financial aid for Fukushima after the earthquake and tsunami may affect the input decision-making and thereafter the outcome variables. However, there were a smaller number of subsidies and compensation from public sectors for rice farmers in western part of Fukushima (Aizu area), compared to coastal areas called *Hama-dori* where the nuclear power plants were located. Tokyo Electric Power company gives mainly financial support for radioactive materials detection tests for Aizu area. We assume that using the data from Aizu area enables us to identify the direct effects of the reputational loss due to the accident.

& Sauvagnat, 2016). We assume the supply chain disruption due to the earthquake and tsunami does not confound our estimation strategy. Furthermore, a catastrophic flood struck near Fukushima in September 2015 which may have reduced agricultural production, but the census survey in 2015 was conducted in February. The information collected in the data is not affected by the flood. Finally, farmers in Japan receive various types of subsidies which may affect their decision-making in doing agriculture. However, participation in some direct payment programs is based on community decisions (Takayama, Nakatani, et al., 2021). Although we do not have farm-level information about the subsidies, we account for the endogeneity, by including farm household-level fixed effects. Hence, we assume that the above concerns should not cause serious problems in the interpretation of the estimation.

5. Reputational loss of farmers' rice production in Fukushima

This section estimates the reputational impact of the Fukushima nuclear accident on the rice production of Fukushima prefecture. Sections 5.1 and 5.2 show the results of our baseline specification, TWFE, and find that the reputational loss due to the accident decreased by 12.4% of rice revenue. The following sub-sections discuss mechanisms of the reputational impacts and what kind of farmers are more affected by the reputational loss.

5.1. Impact of the reputational loss on agricultural output and input

Table 2 reports the estimates from Equation (2). Column (1) examines the reputational effect of the Fukushima nuclear accident on the IHS of rice revenue and shows that 12.4% of annual rice revenue is lost after the accident in Fukushima prefecture compared to Niigata prefecture. Although the event study analysis does not always verify the parallel trend assumption for Column (1) as shown in Figure A3, only the estimate in 1995 is significant indicating that the revenue in the past 10 years before the accident would satisfy the parallel trend assumption.

Next, Columns (2) to (5) show the effects of the accident on agricultural input decisions. They reveal that the accident led to a 3.9 % reduction in paddy fields for Fukushima farmers compared to those in Niigata (Column (2)). In addition, Column (3) indicates a 6.7% decrease in cultivated paddy fields due to the accident. Furthermore, the coefficients of the accident are significant and positive in Columns (4) and (5). Column (4) indicates that the farmland rented out increased by 16.4% after the accident. Moreover, Column (5) shows that the paddy-field rent out increased by 22.3% after the accident. They suggest that collective reputation increases rent-out farmland as well as reduces cultivated land size in both the total and paddy fields. The results confirm our hypothesis that reputational loss reduces agricultural input. The findings highlight the significant and economically impactful influence of reputational damage on farmers' input-related decision-making. Despite government assurances on product quality, the reputational loss persists in output and input in agriculture for four years after the nuclear accident.

Table 2 Effect of the accident on farmers' decision-making (TWFE)

	(1) Rice revenue	(2) Cultivated paddy field	(3) Total field rent out	(4) Paddy field rent out
Accident	-0.124**	-0.060**	0.164**	0.223***
	(0.593)	(0.027)	(0.070)	(0.066)
Household FE	*Yes*	*Yes*	*Yes*	*Yes*
Year FE	*Yes*	*Yes*	*Yes*	*Yes*
Control variables	*Yes*	*Yes*	*Yes*	*Yes*
Parallel trend	*No*	*Yes*	*Yes*	*Yes*
Obs	39,558	39,558	39,558	39,558

Note: Two-way cluster standard errors at household and rural community level in parenthesis. *, **, and*** denote significance at the 10%, 5%, and 1% level, respectively. The outcome variables are transformed by inverse hyperbolic sine. Control variables include age and sex of household head, household size, dummy variables of incorporated farmers, farmers who gain non-farm income, and self-sufficient farmers. The results of the event study analysis are in Figure A3.

5.2. Reputational effects on the adoption of high-value-added agriculture

In this section, we investigate what kind of farmers are more affected by the loss of collective reputation. We estimate the effects of the accident on the decision to environmentally friendly agriculture which has a premium in a market and increases the reputation of the product.

Column (1) of Table 3 presents the negative coefficient of the accident for non-pesticide farming. It indicates that the reputational loss reduces 12.9% of the likelihood of adopting non-pesticide farming, which is one of the organic farming practices. Column (2) also demonstrates that the coefficient of the accident is negative and statistically significant, indicating that the reputational loss reduces the probability of adopting manure fertilizer by 15.9%. Furthermore, Column (3) shows a statistically significant coefficient of -0.065 for Fukushima, indicating a 6.5% decline in the adoption of compost soil farming due to the accident's collective reputation damage from information friction.

The results suggest that the reputational loss due to the accident affects and decreases eco-friendly agricultural practices which are perceived as high value by consumers. This result is consistent with one related study showing that informational barriers were the primary factor explaining lack of technology adoption (Bloom et al., 2013). The plausible explanation of the result could be that reputational effects make members' effort levels strategic complements (Swank & Visser, 2023). It means that farmers reduce their farm investment to adjust the decline of the collective reputation. The event study analysis confirms that at least the estimation for compost soil farming meets the parallel trend assumption (Figure A3).

Table 3 Reputation effect on eco-friendly farming (TWFE)

	(1) Non-pesticide	(2) Manure fertilizer	(3) Compost soil
Accident	-0.129***	-0.159***	-0.065***
	(0.023)	(0.023)	(0.018)
Household FE	*Yes*	*Yes*	*Yes*
Year FE	*Yes*	*Yes*	*Yes*
Control variables	*Yes*	*Yes*	*Yes*
Parallel trend	*No*	*No*	*Yes*
Obs	28,501	28,501	28,501

Note: Two-way cluster standard errors at household and rural community-level in parenthesis. *, **, and*** denote significance at the 10%, 5%, and 1% level, respectively. The outcome variable is a dummy variable. Control variables include age and sex of household head, household size, dummy variables of incorporated farmers, farmers who gain non-farm income, and self-sufficient farmers. The results of the event study analysis are in Figure A3.

5.3. Heterogeneous collective reputation

Finally, we can also consider the possibility that the reputational loss differentially affected farming practices on the basis of livelihood dependence on agriculture. Table 4 shows the heterogeneity impacts of the reputational loss across livelihood dependence on agriculture. From Columns (1) to (4), we conduct a sub-sample analysis including farm households who have at least one full-time farmer. From Column (5) to (8), the sub-sample analysis includes only farm households without full-time workers. The results show that the reputational loss significantly increases cultivated paddy field for full-time farmers but does not affect rice revenue and size of farmland rented out in Columns (1) to (4).

In contrast, the loss of collective reputation significantly decreases rice revenue and size of cultivated puddy field for part-time farmers while it increases size of total and paddy field rented out for part-time farmers in Columns (5) to (8). Cultivated field for full-time farmers increased by 21.7% after the accident while the cultivated filed for part-time farmers decreased by 9.6%.

The results suggest that the land rental market functioned as an adaptive strategy after the Fukushima nuclear accident. The part-time farmers rent out their land while the full-time farmers rent in the land in response to the reputational loss. The reputational loss would enhance the land rental market as it pushes small-scale farmers who may also be vulnerable to economic shocks to scale down their farming and exit from agriculture. Individual reputation could mitigate collective reputation loss (Bai et al., 2022). Full-time farmers have such an established individual reputation that they could keep farming and sell their products to markets. Moreover, the results indicate that full-time farmers may have made up for the damage caused by the price drop due to reputational damage by renting more land and increasing production.

Table 4 Heterogeneity by livelihood dependence on agriculture

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Full-time farming				Part-time farming			
	Rice revenue	Cultivated paddy field	Total field rent out	Paddy field rent out	Rice revenue	Cultivated paddy field	Total field rent out	Paddy field rent out
Accident	-0.009	0.217**	-0.123	0.048	-0.133*	-0.096***	0.182**	0.235***
	(0.096)	(0.099)	(0.170)	(0.145)	(0.066)	(0.026)	(0.071)	(0.069)
Household FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Year FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Control variables	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Obs	3,150	3,150	3,150	3,150	34,675	34,675	34,675	34,675

Note: Two-way cluster standard errors at household and rural community-level in parenthesis. *, **, and*** denote significance at the 10%, 5%, and 1% level, respectively. Control variables include age and sex of household head, household size, dummy variables of incorporated farmers, farmers who gain non-farm income, and self-sufficient farmers

6. Conclusions and policy implications

This study provides robust evidence that reputational loss, driven by negative environmental externalities, significantly influences farmers' decision-making. In the context of the Fukushima nuclear accident, we find that reputational loss reduced the adoption of high-value-added agricultural practices. To our knowledge, this study is among the first to establish a causal relationship between reputational loss and producers' input decision-making, shedding light on how externalities affect investment behavior in agriculture.

Two key policy implications arise from our findings. First, reputational loss can affect farmers' decision-making, even when government inspections and quality assurances confirm product safety. This underscores the economic importance of collective reputation as an externality that influences markets beyond direct physical or environmental damage. Policymakers should recognize that protecting collective reputation is essential to make agriculture sustainable, particularly in regions where geographical branding plays a vital role.

Second, our results demonstrate that reputational loss reduces incentives for farmers to adopt high-value-added practices, such as eco-friendly farming. These practices are critical for enhancing a sustainable environment. Addressing reputational crises requires targeted interventions, such as improving traceability, and promoting third-party certification systems (Winfree & McCluskey, 2005).

Beyond these findings, several open questions remain. It is unclear whether the observed impacts of reputational loss are tentative or if they have long-term effects on agricultural practices, land use patterns, and biodiversity conservation. In addition, the role of individual reputation as a mitigating factor for collective reputation loss requires further investigation. Future research could explore these dimensions using longitudinal datasets or comparative case studies to deepen our understanding of how reputational dynamics shape economic behavior.

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Appendix

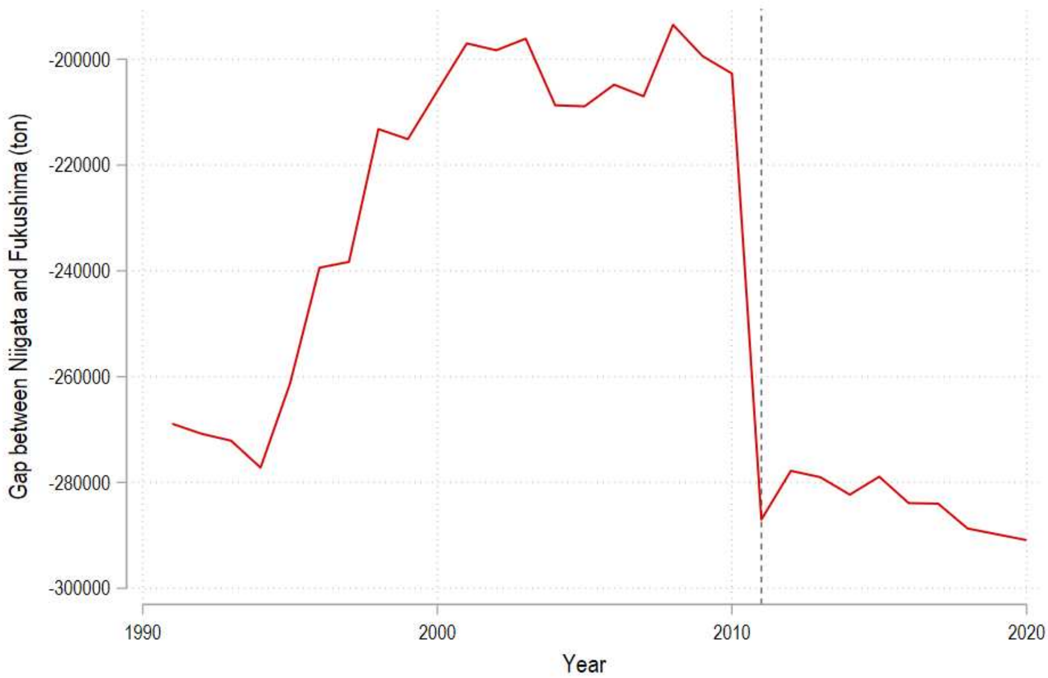


Figure A1 Gap in rice production between Fukushima and Niigata (ton)

Source: Author's calculation based on Statistics of Agricultural Income Produced by MAFF.[12]

[12] The dataset is available from E-stat of Government of Japan. The link is as follows https://www.e-stat.go.jp/stat-search/files?page=1&layout=datalist&toukei=00500215&tstat=000001013427&cycle=0&tclass1=000001032288&tclass2=000001034728&tclass3val=0.

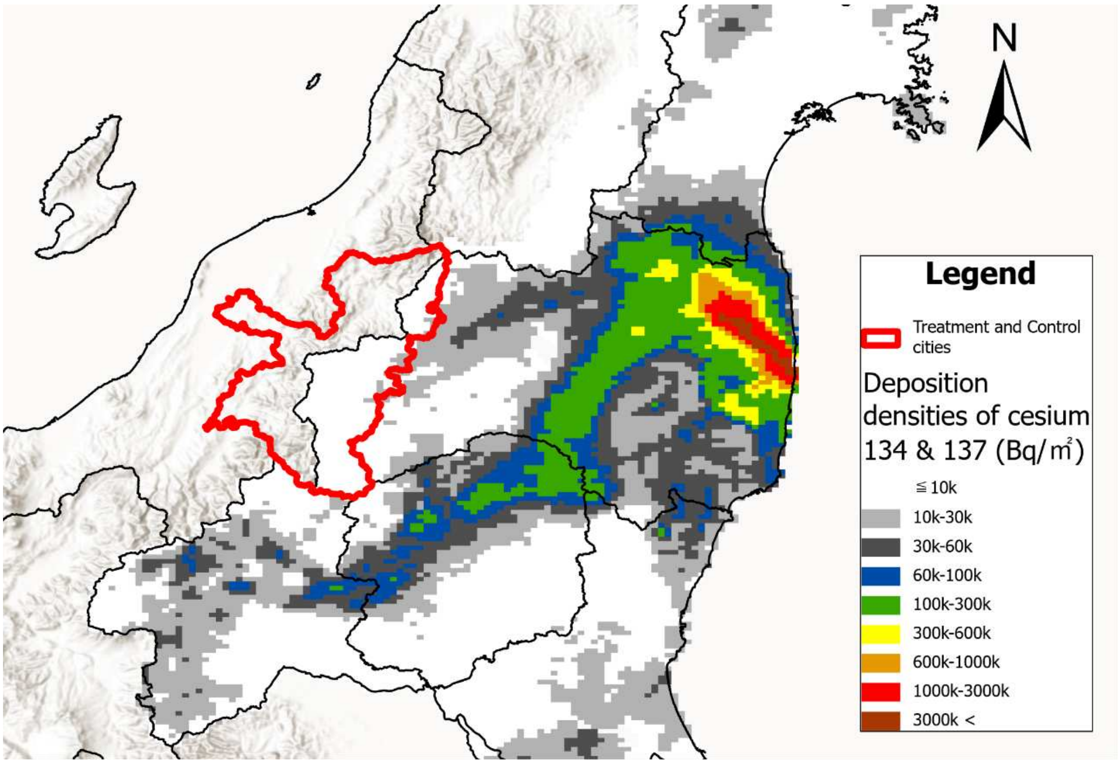
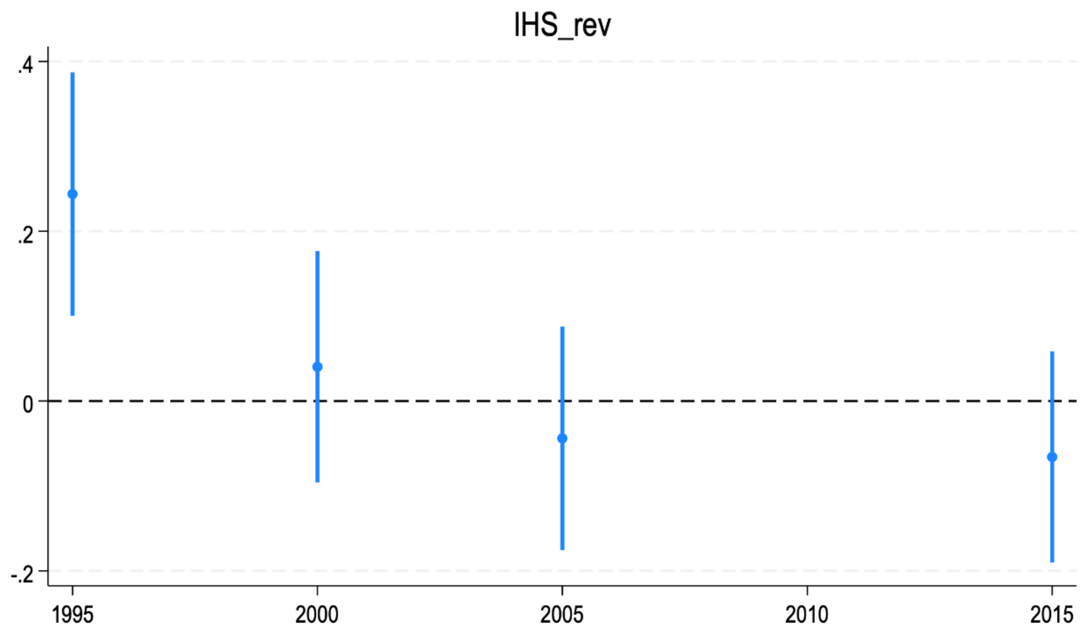


Figure A 2 Distribution of radioactive cesium deposition in December 2012

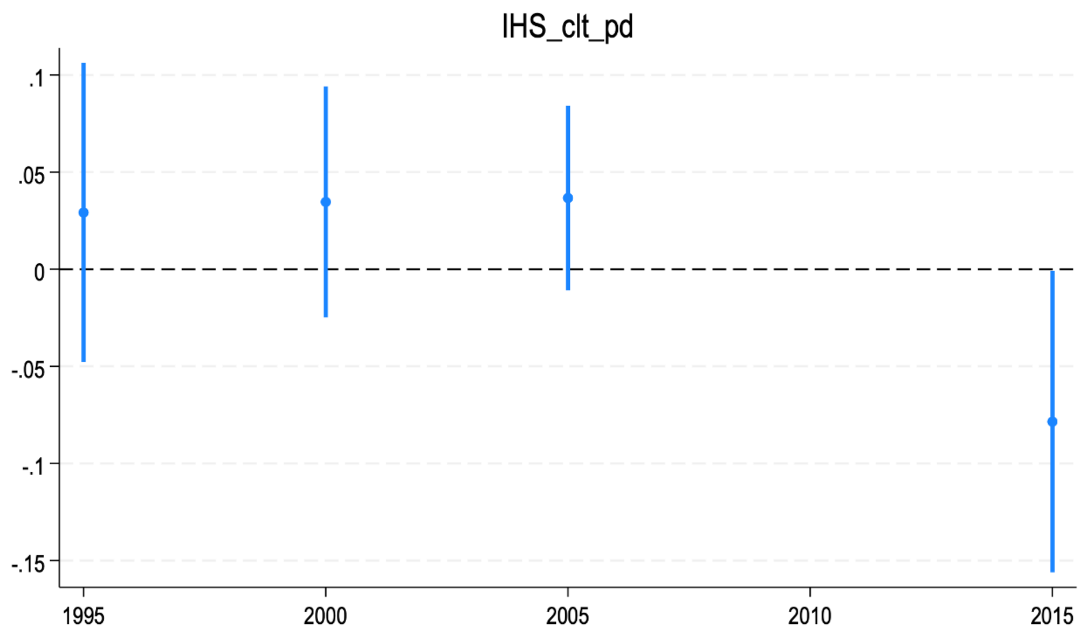
Source: Authors calculation based on “Measurement results of radioactive cesium deposition from the 6th airborne monitoring and airborne monitoring outside the 80 km radius of the Fukushima Daiichi Nuclear Power Plant” published by Japan Atomic Energy Agency.

Note: The data we use is the latest version of the airborne monitoring survey on the distribution of radioactive materials, covering a wide area.

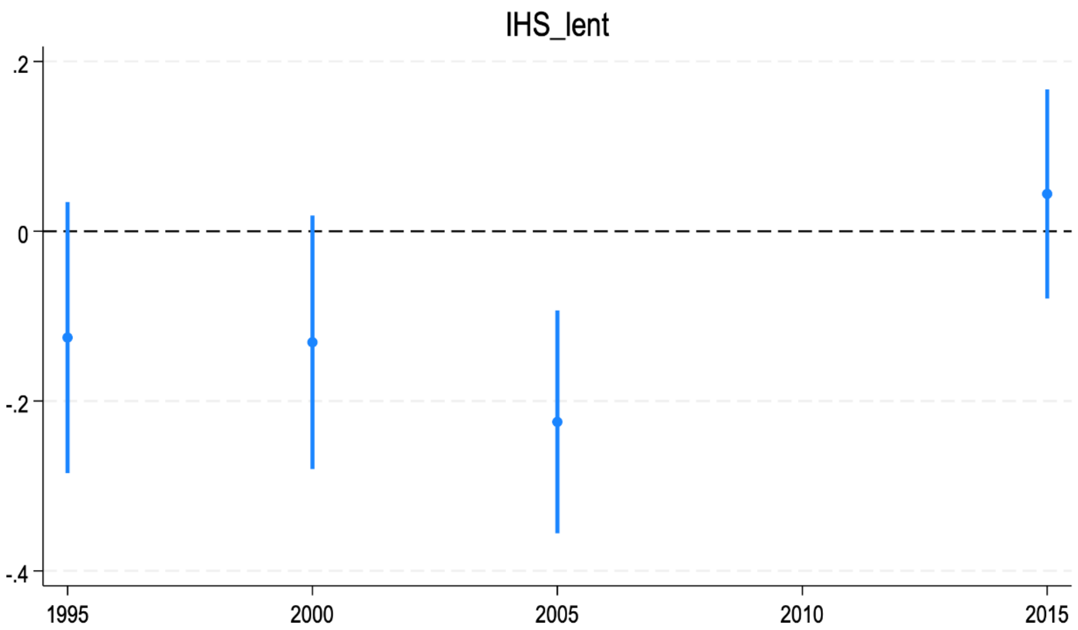
Panel 1 Rice revenue



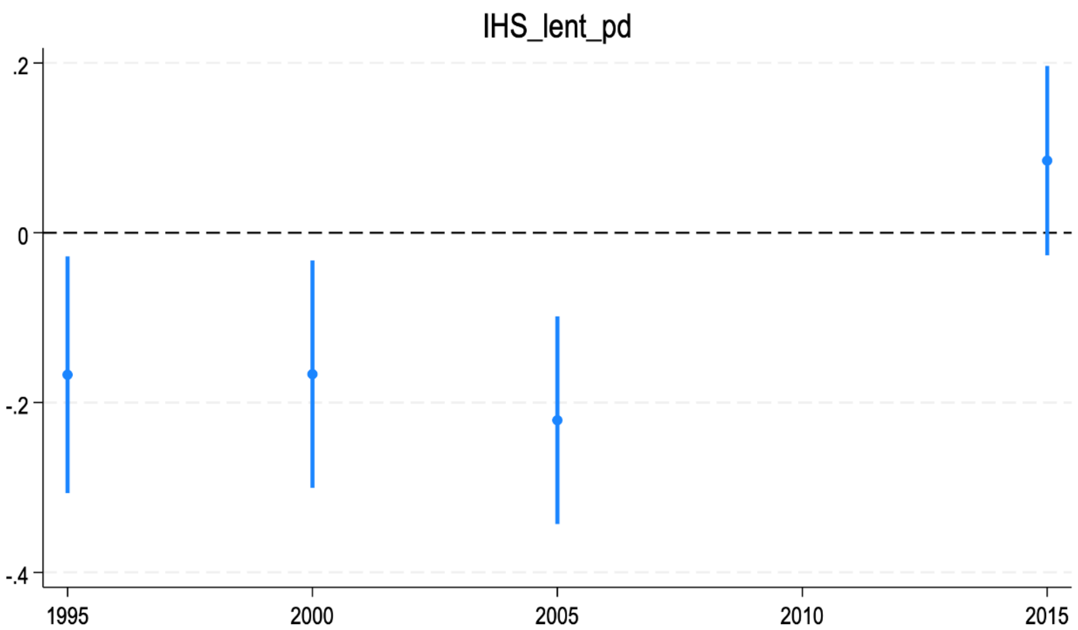
Panel 2 Cultivated paddy field



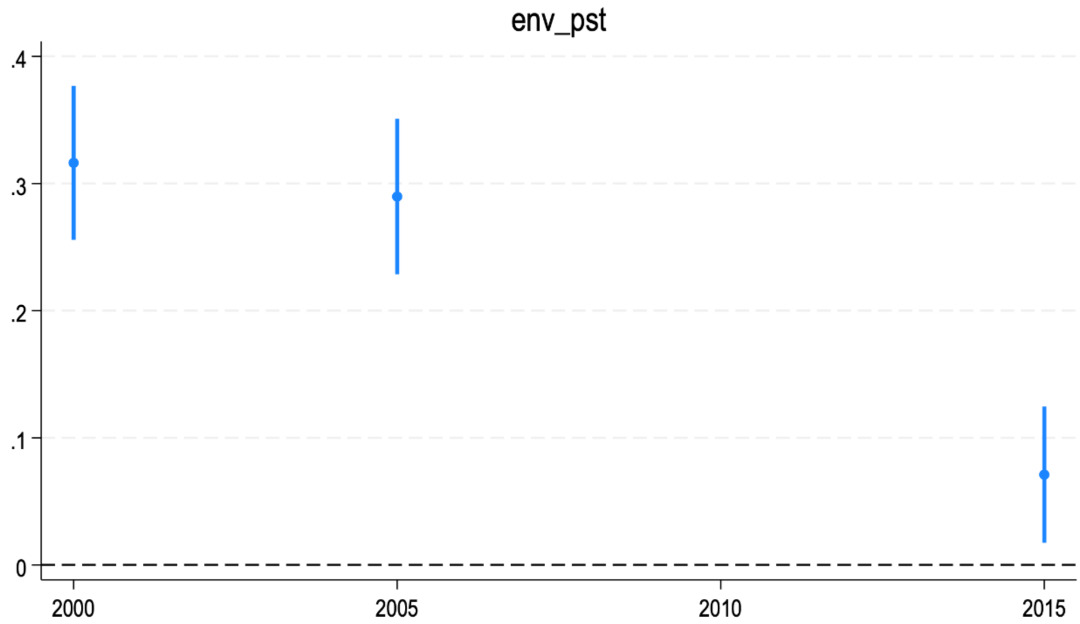
Panel 3 Total field rent out



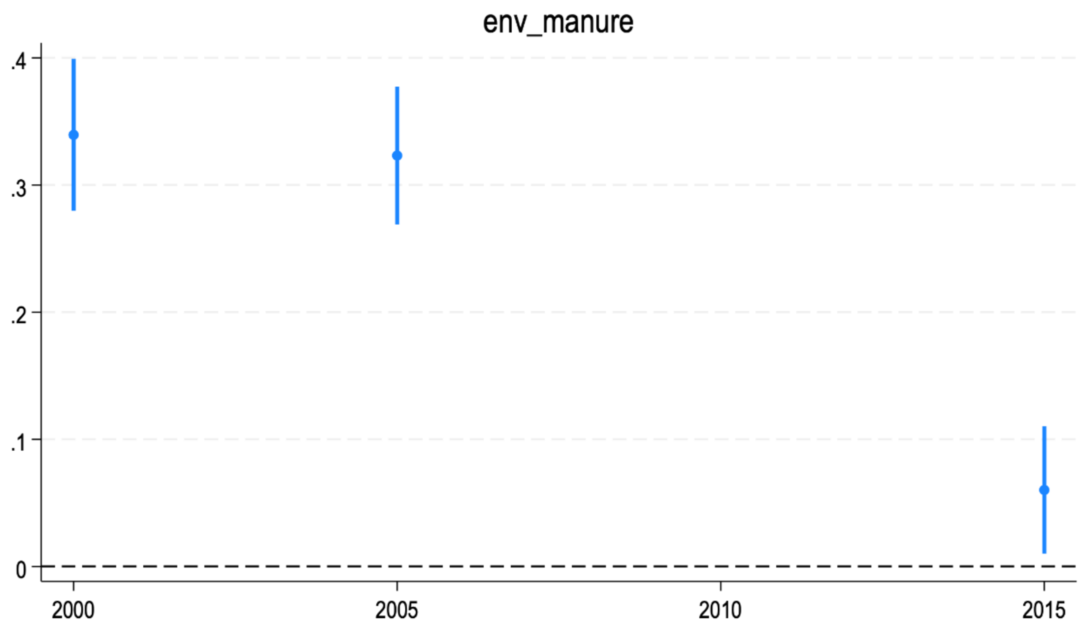
Panel 4 Paddy field rent out



Panel 5 Non-pesticide



Panel 6 Manure fertilizer



Panel 7 Compost soil

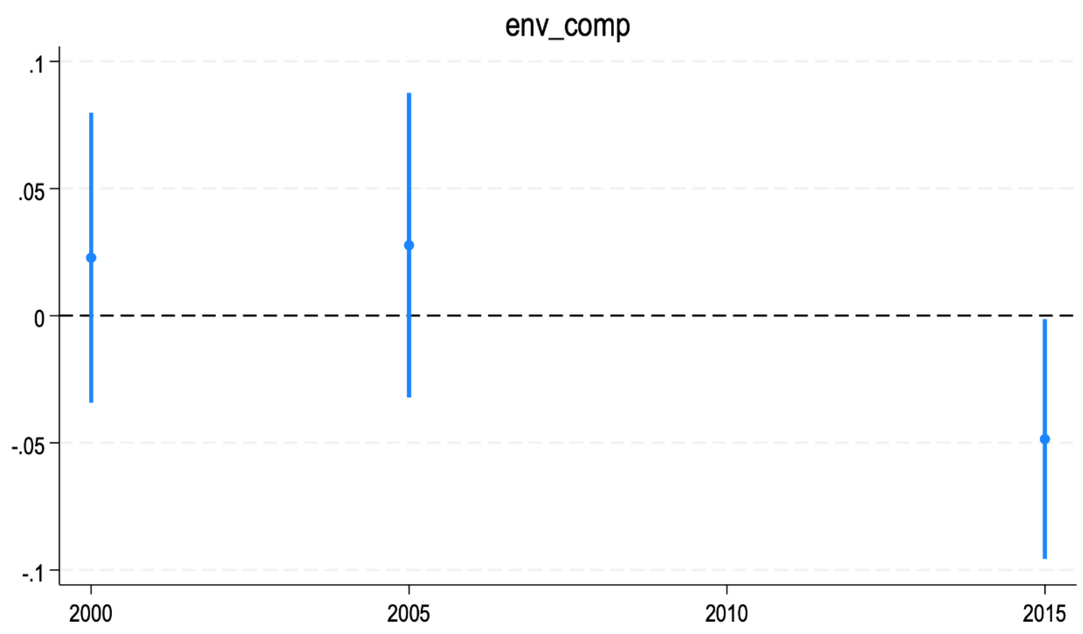


Figure A3 Event study by the Fukushima nuclear accident

Note: Each panel displays event studies with rice revenue (panel 1) cultivated paddy field (panel 2), total field rent out (panel 3), paddy field rent out (panel 4), non-pesticide (panel 5), manure fertilizer (panel 6), and compost soil (panel 7). The unit of observation is household. Each panel shows event studies based on TWFE OLS. All specifications include the household and year fixed effects. Standard errors are clustered at the household and rural community level.