Discussion Paper No. 2012-07

Public perceptions of earthquake risk and its impact on land pricing: The case of the Uemachi fault line in Japan[1]

November, 2012

Tao Gu, Hitotsubashi University
Masayuki Nakagawa, Nihon University
Makoto Saito, Hitotsubashi University
Hisaki Yamaga,[2] Kwansei Gakuin University

Abstract: In this paper, we explore how asset pricing reflects public perceptions of earthquake risk using officially appraised prices of land situated along the Uemachi fault, lying along a north-south axis in the east of Osaka prefecture in Japan. We find that active fault risk has been included significantly in land pricing, only since residents and even policymakers first realized considerable earthquake risk involved in the land along the Uemachi fault by observing that in January 1995, the earthquake driven by the Rokko-Awaji fault had catastrophic damages on the southern part of Hyogo prefecture. We estimate that nonresidential land prices along the Uemachi fault are discounted by 4 percent for every 100 meters closer to the fault line.

Key words: active faults, earthquake risk, hedonic land pricing, public perceptions.
JEL classification: R14, R22, D80.

[1] The authors would like to thank Shinsuke Ikeda, Shingo Nagamatsu, Fumio Ohtake, Shiba Suzuki, Kan Takeuchi, seminar participants at the autumn 2010 meeting of the Japanese Economics Association, Osaka and Hitotsubashi Universities and the Research Institute of Economy, Trade, and Industry for helpful and encouraging comments. The authors also gratefully acknowledge a grant-in-aid from the Program for Promoting Social Science Research Aimed at Solutions of Near-Future Problems from the Japanese Ministry of Education, Culture, Sports, Science, and Technology.

[2] Correspondence to: Hisaki Yamaga, School of Economics, Kwansei Gakuin University, 1–155 Uegahara Ichiban-cho, Nishinomiya, 662-8501, Japan. Phone: +81–798–54–6139. Fax: +81–798–51–0944. E–mail: yamaga@kwansei.ac.jp

1. Introduction

On January 17, 1995, major slippage of the Rokko–Awaji fault line caused catastrophic damage to the southern part of Hyogo prefecture in Japan, with a death toll of 6,434 people. A wide range of media intensively covered this calamitous fault-driven earthquake, now known as the Hanshin–Awaji earthquake. In addition, many seismology experts provided the public with comprehensive information on the potential danger of active fault lines. Since then, the public have become more acutely aware of how ubiquitous risky active faults are throughout Japan.

In Osaka prefecture, an area adjoining the east of Hyogo prefecture, the local administration and residents alike abruptly realized the potential danger of their own Uemachi fault line, a fault lying along a north-south axis in the eastern part of Osaka prefecture (see Figure 1). Although researchers since the early 1970s had recognized this active fault as one of the most dangerous faults in Japan, the Osaka prefectural government had focused exclusively on preparations for ocean trench-driven earthquakes without paying any close policy attention to the Uemachi fault. Accordingly, the public had been wholly ignorant of the risk of an earthquake along the Uemachi fault line up until the activation of the Rokko–Awaji fault line in January 1995.

Exploiting this drastic change in public attention to the Uemachi fault line, from a position of almost complete ignorance to acute awareness, we explore how asset pricing reflects revised perceptions about earthquake risk using the prices of land located along the active fault. Because this fault zone was not subject to any serious direct damage from the Hanshin–Awaji earthquake, after controlling for other possible effects on land pricing, we can attribute any decrease in the prices of land close to the active fault to these revised perceptions of earthquake risk.

For this purpose, we use the publication *Published Land Prices*, officially evaluated by certified appraisers for nationwide points of observation every year since January 1970 to the present, and compiled by the National Land Agency (NLA).[3] The NLA typically reappraises the land each year after it selects a point of observation, with around 200 to 500 data points situated along the Uemachi fault line for the sample period between 1983 and 2009. Using continuous observations for the same location, we can remove to some extent possible biases in our estimation.

We find that following the Hanshin–Awaji earthquake, for a zone within one kilometer on both sides of the Uemachi fault line, land prices decrease as the point of observation gets closer to the fault line. However, before the Hanshin–Awaji earthquake, land pricing along the Uemachi fault did not depend at all on geographic proximity to the fault line. The discounting of land prices immediately above the fault is scarcely marginal. For example, if the price of nonresidential land one kilometer off the fault was 1,000,000 yen per square meter (m^2) in 1996, then the price of nonresidential land with similar characteristics but immediately above the fault was only about 700,000 yen per m^2.

Few studies empirically investigate the effects of the Hanshin–Awaji earthquake on property values. As an exception, Naoi et al. (2009) employ nationwide municipal-level data and conclude the heavier discounting of average land prices in municipalities with higher earthquake risk after the Hanshin–Awaji earthquake. Elsewhere, Nakagawa et al. (2009) use zip code-level data in the Tokyo

[3] Since 2001, the Japanese Ministry of Land, Infrastructure, and Tourism has compiled the *Published Land Prices*.

metropolitan area and find that land prices decrease with earthquake risk for a sample period between 1980 and 2001. However, they also find that the negative relationship between land pricing and earthquake risk remains despite the Hanshin–Awaji earthquake.

Outside of Japan, several studies draw on US property data to evaluate real estate valuations before and after selected natural disasters. For example, Bin and Polasky (2004) conclude the heavier discounting of houses located on a floodplain in eastern North Carolina after hurricane Floyd hit in September 1999. Likewise, Beron et al. (1997) present evidence of an upward revision in housing values after the Loma Prieta earthquake in the San Francisco Bay area in October 1989. Finally, Brookshire et al. (1985) demonstrate the significant discounting of housing prices in zones with high earthquake risk disclosed in an earthquake hazard map made available by the State of California in 1974.

When compared with the above studies, our rich dataset comprising continuous observation of land prices at the same location allows us to better identify the source of earthquake risk and the timing with which a specific event (here the Hanshin–Awaji earthquake) impacts land pricing. Most importantly, it is possible for us to specify which particular aspect of public risk perceptions changed in response to the Hanshin–Awaji earthquake. In addition, we can explore whether this drastic change in risk perceptions exerted a permanent effect on land pricing because of the relatively long-run nature of our dataset.

The remainder of the paper is organized as follows. In Section 2, we describe how drastically the public changed perceptions about the risk of active fault-driven earthquakes with the Hanshin–Awaji earthquake. We present the estimation results in Section 3 and offer our conclusions in Section 4.

2. Drastic changes in public perceptions about the Uemachi fault line

2-1 Policy attitudes to the Uemachi fault line after the Hanshin–Awaji earthquake

The Uemachi fault line, about 42 kilometers in length, lies along a north-south axis in the eastern part of Osaka prefecture (see Figure 1). Academic researchers initially recognized the presence of this large active fault using exploratory drilling conducted in the early 1970s. In the 1980s and the first part of the 1990s, they obtained almost a full picture of the active fault line together with several fault branch lines through further intensive geological surveys.

The central and local governments in Osaka prefecture, however, paid scant attention to research on the Uemachi fault line before 1995. A major reason for their inattention was that they were scarcely interested in *inland fault-driven earthquakes*. In fact, prior to the Hanshin–Awaji earthquake, the greatest concern for both central and local policymakers was to prepare for *ocean trench-driven earthquakes*. In particular, several government agencies, including the Japanese central government's Headquarters for Earthquake Prediction, and national universities allocated tremendous amounts of research resources to the prediction of earthquakes of ocean origin.

Before 1995, the Osaka prefectural government also decided on a master plan for the prevention of possible damage caused by large-scale earthquakes originating off the Kii peninsula in the Pacific Ocean. However, it did not formulate any prevention measures for inland fault-driven earthquakes. The municipal governments in Osaka prefecture also never released any hazard maps of active fault lines under their own initiative, even though the Geographical Survey Institute, a central government agency, had completed detailed hazard maps covering the Uemachi fault line. Consequently, the residents of Osaka prefecture were almost completely unaware of the presence of the Uemachi fault line. However, policy attitudes toward active faults in general and the Uemachi fault in particular changed drastically with the occurrence of the fault-driven Hanshin–Awaji earthquake in January 1995. In response to the swing in the policy pendulum, the residents of Osaka prefecture have become extremely attentive to the Uemachi fault located in their own geographic area.

In response, the Japanese central government almost immediately reorganized the Headquarters for Earthquake Prediction as the Headquarters for Earthquake Research Promotion (HERP), thereby shifting policy resources from the prediction of ocean trench-driven earthquakes to prevention measures for inland fault-driven earthquakes. In 1997, the Osaka prefectural government conducted intensive geological surveys on the Uemachi fault line, and estimated the possible damage arising from the slippage of the Uemachi fault (Osaka Prefectural Government, 1997). In addition, the HERP publicly disclosed a more concrete picture of what would happen if the Uemachi fault line were reactivated (HERP, 2004). The HERP estimated that the time since the most-recent fault activity was between at least 9,000 and 24,000 years, and that the timing of the next event was well above the average for two consecutive earthquake events (8,000 years).

Based on these estimates, the HERP forecasted that the fault would reactivate within the next thirty years with a probability of between 2 and 3 percent, and within the next hundred years with a probability of between 6 and 10 percent. Among the possible scenarios presented by the HERP was that if the entire fault line slipped, then an earthquake with a magnitude in excess of 7.5 on the Richter scale would shake the fault zone, and that the bedding plane immediately above the fault line would slide either eastwards or westwards, generating a throw of about three meters in height. Based on the survey evidence, the HERP then classified the Uemachi fault line as one of the riskiest faults in Japan.

2-2 Changes in public perceptions about active faults following the Hanshin–Awaji earthquake

The intensive media coverage of the fault-driven Hanshin–Awaji earthquake also helped to change drastically public perceptions about active faults in general. According to Yamaguchi (2008), Nippon Hoso Kyokai (NHK), Japan's national public broadcasting agency, first covered news about 'active faults' when reporting on the Los Angeles earthquake in 1987, and had since covered topics relating to active faults at a rate of at most four times per year up to 1994. However, just in 1995, NHK broadcasted news about active faults 66 times. In the second half of the 1990s and the 2000s, NHK provided news on active faults more frequently. On this basis, Yamaguchi (2008) concludes that 'active faults' had been recognized socially for the ten years after 1995. That is, in response to the Hanshin–Awaji earthquake, the public underwent a permanent change in its perceptions about active faults.

As documented in Okada (2008), books on active faults sold extremely well among general readers following the Hanshin–Awaji earthquake. According to the University of Tokyo Press (UTP), *Active Faults in Japan: A New Edition*, published by UTP in 1991, sold at 35,000 yen per copy, with the number of copies sold falling from 2,934 in 1991 to 255 in 1992 and 185 in 1993. However, even though it was relatively expensive, 2,791 copies were sold in 1995 and 4,539 in 1996. A much cheaper version of the same text, *The Map of Active Faults in Japan*, published by UTP in 1992 sold at 4,500 yen per copy. In 1995, UTP sold 5,241 copies, but only 939 copies in 1992 and 145 copies in 1993. Similarly, in 1996 UTP published another book, *What is an Active Fault?*, which was sold at 1,800 yen per copy, and selling 9,074 copies in its first year.

As described, the intensive media coverage of the fault-driven Hanshin–Awaji earthquake drastically changed public perceptions about active faults in general. Together with the thoroughly revised policy stance discussed earlier, this enabled the residents of Osaka prefecture to become much more aware of the potential danger of the Uemachi fault line than they had before the Hanshin–Awaji earthquake.

3. Data and estimation

3-1 Land prices and the set of explanatory variables

For land prices, we use the publication *Published Land Prices*, officially evaluated by certified appraisers for nationwide points of observation every year since January 1970 to the present, and compiled by the National Land Agency (NLA). In evaluating property lots not recently transacted, the appraisers consider market prices quoted for land in the neighborhood of the place of observation.[4] Once the NLA selects a particular data point for observation, it is valued continuously from then on unless there is a special reason to terminate valuation. The NLA also sometimes adds data points. In particular, the NLA has greatly expanded the set of data points included since the mid-1990s. Hence, the dataset on *Published Land Prices* displays an expanding but incomplete panel structure. For estimation purposes, we mainly use the dataset year by year as cross-sectional data for the period between 1983 and 2009. However, we also exploit the panel data nature of the dataset to examine the robustness of these estimation results.

It may be difficult to identify the effect of active fault risk on land pricing for data points fairly far from the Uemachi fault, because other possible effects on land prices are likely to dominate. We thus restrict our sample points of observation to those relatively close to the Uemachi fault line. According to Usui (2000), the construction damage observed with the Hanshin–Awaji earthquake concentrated heavily on an area within two kilometers of the Rokko–Awaji fault line on both sides. For this reason, we select two sets of samples comprising data points within one and two kilometers of the Uemachi fault line on both sides and mainly report the estimation results of the former set as long as there is no substantial difference between the two sets.

As reported in Table 1, the number of observation points for the within-one (within-two) kilometer zone is 165 (262) in 1983, 293 (453) in 1994, 323 (512) in 1996, and 318 (515) in 2009. Given the time-series change in the number of observation points, it is necessary to separate the effect of the 1995 Hanshin–Awaji earthquake from that associated with the increase in the total

[4] Shimizu and Nishimura (2006) point out that the appraisers are relatively conservative and tend to select the quoted price with the smallest change of the nearby market transactions. Thus, the *Published Land Prices* are likely to reflect the true market valuation, but with a substantial lag. Hence, if we find the immediate impact of the Hanshin–Awaji earthquake on land pricing in the Uemachi fault zone, then we can interpret such a finding as representing robust evidence of the impact of earthquake risk.

number of data points in the mid-1990s. Figure 1 depicts the data points of observation in 1995 together with the location of the Uemachi and Rokko–Awaji fault lines.

The prices of land in *Published Land Prices* are as at January 1, and therefore there is in principle no allowance for the impact of the 1995 Hanshin–Awaji earthquake in the land pricing for 1995 as it took place on January 17, 1995. As discussed later, however, some of the information associated with the Hanshin–Awaji earthquake might have been included in the 1995 land pricing data before its public release in March 1995.

We apply a standard hedonic pricing approach year by year to the cross-sectional data in the *Published Land Prices* for the period between 1983 and 2009. We specify the natural logarithm of the price of land per m^2 as the dependent variable. A major explanatory variable is the shortest distance between the data point of observation and the Uemachi fault line.[5] We use this to examine the discounting of land prices according to geographic proximity to the active fault line. We then compare the estimation results for this parameter before and after the Hanshin–Awaji earthquake.

The choice of the other explanatory variables follows the existing literature (see Nakagawa et al., 2009). From the dataset of *Published Land Prices*, we construct a dummy variable for residential use, the legally required bulk ratio (the ratio of the total floor area to the site area), the road distance to the nearest railroad station, and the width of the road in front of the land. We calculate the time distance from the nearest station to Osaka Station representing the center of the Osaka business district using the 2009 train timetable.[6] In addition, we employ the average household income at the zip code level as a proxy for the residential environment and regional segmentation.[7] To identify any differences between residential and nonresidential areas, we include cross products for the dummy variable indicating residential use and the remaining explanatory variables. Table 1 provides basic statistics for the dependent and explanatory variables.

3-2 Main estimation results

Table 2-1 reports the cross-section estimation results for the within-one-kilometer zone for the sample period between 1983 and 2009. Along with the estimated coefficients for the distance to the fault line, the signs of most of the estimated coefficients are reasonable and consistent with our expectations, though some of the estimates are not statistically significant. In sum, the land price is higher the closer a point of observation is to the nearest station, the shorter the travel time to Osaka Station, and the higher average income in the corresponding zip code area. Land prices also increase with the legally required bulk ratio, particularly in nonresidential areas, and with the width of the road, especially in residential areas.

Figure 2 plots the time series of the estimated coefficient for the distance to the fault line with 95 percent confidence intervals for nonresidential areas within one kilometer of both sides of the fault line. According to this figure and Table 2-1, the estimated coefficients for distance (measured in meters) to the fault line in nonresidential areas are insignificant prior to 1994, and even negative

[5] A digital map of the Uemachi fault line is provided by the National Institute of Advanced Industrial Science and Technology (NIAIST, 2009).

[6] For this purpose, we use a computer program provided by the VAL Institute (http://val.co.jp/).

[7] The zip code-level data for household income are compiled by Urban Dynamic Software, Inc. (http://www.uds.co.jp/).

prior to 1991. That is, there is no evidence that land prices decreased with geographic proximity to the fault line up until 1994. However, the coefficients are significantly positive at the 0.05 level of significance in 1995 and at the 0.01 level in 1996 and after.

The point estimate of the coefficient for the distance to the fault line is greater than 0.0004 in 1996 and after. This implies the discounting of nonresidential land prices by more than 4 percent when a point of observation gets closer to the fault line by 100 meters. Put differently, using the point estimate of 0.000430 from 1996, if the price of nonresidential land one kilometer from the fault is 1,000,000 yen per m^2, then the price of nonresidential land with similar characteristics immediately above the fault is about 700,000 yen per m^2, or a discount of 300,000 yen per m^2.

The estimated coefficients for the cross products of the residential dummy variable and the distance to the fault line are significantly negative for the period between 1996 and 2009. The point estimate is about –0.0003 for the corresponding period. That is, land prices in residential areas decreased with geographic proximity to the fault line, but did not by as much as in nonresidential areas.[8] In addition, the estimated coefficients for the residential dummy variable are significantly positive during the same period. Together, these estimation results imply that from 1996 onwards land prices in nonresidential areas were subject to heavy discounting, not only relative to residential areas, but also according to their geographic proximity to the fault line.

According to the estimation results for the within-two-kilometer zone (Table 2-2), the estimated coefficients for the distance to the fault line are positive at the 0.05 level of significance for the period between 1996 and 1999, and positive at the 0.01 level of significance for the period between 2000 and 2009. Compared with the within-one-kilometer nonresidential zone, the point estimate of the coefficient decreases substantially from more than 0.0004 to around 0.0001 for the period between 1996 and 2009. In addition, the estimation results suggest that land pricing was no longer sensitive to active fault risk in residential areas in 1996 or after.

3-3 On the robustness of the estimation results

Using only continuously appraised points of observation: Below we examine how the above estimation results are robust with respect to alternative samples and specifications. As discussed in Section 2, the NLA expanded the number of points of observation for the *Published Land Prices* in the mid-1990s, a period overlapped with the timing of the Hanshin–Awaji earthquake. For example, the number of points within one kilometer of the fault line increased from 247 in 1993, to 293 in 1994, and to 324 in 1995. To control for the possible effects of the increase in observations, we estimate the same equation as earlier using only those points of observation appraised continuously between 1993 and 2009 or between 1993 and 1997. Consequently, in the case of the within-one-kilometer zone, the number of observation points fell to 175 for the period between 1993 and 2009 and to 228 for the period between 1993 and 1997.

The estimation results do not change substantially except for the within-two-kilometer zone for the 1993–97 samples (see Tables 3-1 and 3-2). In the case of the within-one-kilometer zone, the estimated coefficient for the distance to the fault line is statistically insignificant in 1993 and 1994,

[8] Using zip code-level data for the Tokyo metropolitan area, Nakagawa et al. (2009) report that land pricing is more sensitive to earthquake risk in nonresidential than residential areas.

but positive at the 0.05 level or lower from 1996 onwards and at the 0.10 level in 1995. On the other hand, in the case of the within-two-kilometer zone, the estimated coefficient for the distance to the fault is insignificant from 1993 through to 1995 and significant only at the 0.10 level for the period between 1996 and 1998. Note that in either case, there is weaker evidence that land prices decreased with geographic proximity to the fault line in 1995.

Semiparametric estimation: Below we employ semiparametric estimation as an alternative specification. We apply a nonparametric specification to the effect with respect to the distance to the fault line, but continue to assume linearity with respect to the other explanatory variables, including the cross product of the dummy variable for residential areas and the distance to the fault line. We adopt the difference-based semiparametric estimation proposed by Yatchew (1997) as the estimation strategy, while we apply the local weighted scatter plot smoother (LOWESS) proposed by Cleveland (1979) to the estimation of the nonparametric part.[9]

We apply the above semiparametric estimation to the within-one-kilometer zone, and examine how well the nonparametric part can approximate the effect of the distance to the fault line on land pricing. Table 4 reports the p-values of the test statistics for constancy of the nonparametric part as the null hypothesis. For the sample up to 1995, we cannot reject the null hypothesis at the 0.05 level of significance, but can at the 0.10 level for the 1995 sample. For the 1996 sample and after, we reject the null hypothesis at the 0.05 level or lower.

Figure 3 compares the predicted values of the semiparametric specification with those of the linear specification assuming that the explanatory variables other than the nonparametric part are set at the sample average. As shown, both estimation methods yield quite similar predictions. That is, the linear specification well approximates the effect of the active fault on land pricing.

3-4 Discussion

On this basis, can we conclude the heavy discounting of land prices given geographic proximity to the Uemachi fault line, but *only* since the Hanshin–Awaji earthquake? The answer is a definite yes given the sharp contrast in the estimation results from the *Published Land Prices* released in **1994 and before** and **1996 and after**. This is particularly the case in nonresidential areas within one kilometer of the fault line.

According to the estimation results based on the **1995** sample, however, the estimated coefficients for the distance to the fault line are not always, but sometimes significantly positive, though at a relatively high level of significance (0.05 or higher). As discussed in Section 2, the Hanshin–Awaji earthquake took place on January 17, 1995, while in the 1995 edition of the *Published Land Prices*, the prices were supposed to be as of January 1, 1995. In principle, there was then no allowance for the 1995 sample to incorporate any information triggered by the Hanshin–Awaji earthquake. Does this in turn compromise our basic proposition?

We interpret the estimation results from the 1995 sample in three ways. First, we have for the 1995 sample only weak evidence in support of the effect of the Uemachi fault on land pricing. Once we restrict the points of observation to those appraised continuously during the 1990s, we cannot

---

9 We use the STATA statistical package to conduct the nonparametric estimation.

reject the absence of the effect at the 0.05 level of significance. We also cannot reject the absence of the effect at the 0.05 level using the semiparametric estimation.

Second, there is the possibility that the land pricing partly and slowly incorporated the earthquake risk associated with the Uemachi fault prior to the Hanshin–Awaji earthquake. The occurrence of a major fault-driven earthquake may then have very decisively pushed these underground pricing developments into mainstream movements in appraisal practices.

Finally, there is also the possibility that there was revision in the 1995 version of the *Published Land Prices* before their release in late March 1995. Immediately after the Hanshin–Awaji earthquake, real estate dealers/brokers thoroughly investigated where active faults were located using the nationwide active fault maps compiled by the Geographical Survey Institute. Throughout Japan, this activity set off the speculative sale of land regarded as carrying a high fault risk. The certified appraisers may then have taken into consideration any downward revision on the land lying along the Uemachi fault before making their final report to the NLA. In either of the three cases, the occurrence of the fault-driven Hanshin–Awaji earthquake played a pivotal role in incorporating active fault risks into land pricing.

4. Conclusion

In response to the occurrence of the calamitous Hanshin–Awaji earthquake, central and local governments in Japan drastically changed their attitudes toward earthquakes, putting a policy emphasis on not only *ocean trench-driven earthquakes* but also *inland fault-driven earthquakes*. Alongside the sweeping change in policy attitudes, the intensive media coverage of the fault-driven earthquake made the public suddenly aware of the potential danger of active faults. Against such a social background, local governments and residents in Osaka prefecture became abruptly attentive to the Uemachi fault, which since the early 1970s seismology experts had considered one of the most dangerous in Japan.

Exploiting these dramatic changes in public perceptions of the risk of active faults, from almost complete ignorance to acute awareness, we empirically demonstrate that the earthquake risk associated with the Uemachi fault has been significantly included in land pricing, but *only* since the Hanshin–Awaji earthquake. The impact of the Uemachi fault on land pricing has since been far from marginal. In evidence, if the price of nonresidential land one kilometer off the fault line was 1,000,000 yen per m^2 in 1996, then the price of nonresidential land with similar characteristics, but immediately above the fault, was only about 700,000 yen per m^2, a discount of 300,000 yen per m^2 because of earthquake risk.

The findings presented in this paper strongly suggest that an improper framework of disaster damage prevention may totally mislead public perceptions about the risks of natural disasters. Prior to the Hanshin–Awaji earthquake, the Japanese government focused exclusively on preparation for *ocean trench-driven earthquakes*, particularly their prediction, without paying any significant policy attention to the possibility of equally devastating *inland fault-driven earthquakes*. Misguided by this faulty policy framework, the public failed to utilize the rich scientific knowledge concerning active fault risks that had accumulated since the early 1970s. Accordingly, any reasonable risk-averse behavior was deeply discouraged from developing in the Japanese real estate market.

In contrast, our findings suggest that once a proper policy framework guides the public, they revise voluntarily perceptions about natural disaster risks by utilizing existing scientific knowledge and behave independently in countering and managing the risk of natural disasters. In that case, real estate markets immediately began to incorporate risk-averse behavior into land pricing. According to our estimation results, land pricing in Osaka prefecture quickly reflected the earthquake risk associated with the Uemachi fault within a year of the Hanshin–Awaji earthquake, and has since incorporated this risk permanently.

References

Beron, Kurt, J., James C. Murdoch, Mark A. Thayer, and Wim P. M. Vijverberg (1997) "An analysis of the housing market before and after the 1989 Loma Prieta Earthquake," *Land Economics,* Vol. 73, pp. 101–113.

Bin, Okmyung and Stephen Polasky (2004) "Effects of flood hazards on property values: Evidence before and after Hurricane Floyd," *Land Economics,* Vol. 80, pp. 490–500.

Brookshire, David, S., Mark A. Thayer, John Tschihart, and William D. Schulze (1985) "A test of the expected utility model: Evidence from earthquake risks," *Journal of Political Economy,* Vol. 93, pp. 369–389.

Cleveland, William S. (1979) "Robust locally weighted regression and smoothing scatter plots," *Journal of the American Statistical Association,* Vol. 74, pp. 829–836.

Headquarters for Earthquake Research Promotion, Earthquake Research Committee (2004) *Monthly Reports on Evaluation of Seismic Activities in Japan*, March 10.

Nakagawa, Masayuki, Makoto Saito, and Hisaki Yamaga (2009) "Earthquake risks and land prices: Evidence from the Tokyo Metropolitan Area," *Japanese Economic Review*, Vol. 60, pp. 208–222.

Naoi, Michio, Miki Seko, and Kazuto Sumita (2009) "Earthquake risk and housing prices in Japan: Evidence before and after massive earthquakes," *Regional Science and Urban Economics,* Vol. 39, pp. 658–669.

National Institute of Advanced Industrial Science and Technology (2009) *Active Fault Database of Japan*, DB095, July 23, 2009. http://riodb02.ibase.aist.go.jp/activefault/index.html

Okada, Atsumasa (2008) "Recent trend and perspective for the active fault studies in Japan," *Active Fault Research*, Vol. 28, pp. 7–13. (in Japanese)

Osaka Prefectural Government (1997) *A Report of Estimated Damages in Case of Earthquake with Hypocenter Directly Below Osaka*, reported by Crisis Management Division. (in Japanese)

Shimizu, Chihiro, and Kiyohiko Nishimura (2006) "Biases in appraisal land price information: The case of Japan," *Journal of Property Investment and Finance*, Vol. 24, pp. 150–175.

Usui, Teruko (2000) "GIS analysis of earthquake damage ratio based on the distance from active faults: Building and buried pipe damage in Nishinomiya City in the Hyogoken–Nanbu earthquake," *The Quaternary Research*, Vol. 39, pp. 375–388. (in Japanese)

Yatchew, Adonis (1997) "An elementary estimator of the partial linear model," *Economic Letters,* Vol. 57, pp. 135–143.

Yamaguchi, Masaru (2008) "Active fault in mass medea :How we can use the active fault study and information for our society," *Active Fault Research*, Vol. 28, pp. 123–131. (in Japanese)

Table 1: Basic statistics for the *Published Land Prices* and the set of explanatory variables

		Land price (yen/m^2)	Distance to the fault line (m)		Width of the front road (m)		Bulk ratio(Total floor area/Site area)(%)		Time distance to Osaka station(min)		Road distance to the nearest station(m)		Residential use dummy	Average income (million yen)
Within-one-kilometer zone:			Nonresidential	Residential	Nonresidential	Residential	Nonresidential	Residential	Nonresidential	Residential	Nonresidential	Residential		
	Mean	285009	538.02	462.70	9.91	5.63	386.00	199.83	34.98	40.45	600.40	841.57	0.70	6.16
1983	Std. Dev.	316537	278.61	303.42	10.40	1.80	209.97	65.45	17.89	15.28	632.18	672.19	0.46	0.15
Obs=165	Min	55000	1.94	2.81	1.20	1.20	200.00	80.00	6.00	11.00	0.00	150.00	0.00	5.75
	Max	1930000	986.09	998.07	60.00	15.00	1000.00	400.00	72.00	79.00	3000.00	3300.00	1.00	6.40
	Mean	1151961	446.45	478.94	15.68	5.71	452.73	211.58	29.85	39.30	377.33	848.58	0.62	6.17
1994	Std. Dev.	1953816	284.27	283.66	12.69	1.70	203.51	59.53	16.16	15.22	344.42	660.92	0.49	0.14
Obs=293	Min	139000	11.18	3.72	0.00	3.50	200.00	80.00	6.00	11.00	0.00	120.00	0.00	5.65
	Max	15700000	981.23	988.32	75.00	16.00	1000.00	400.00	70.00	79.00	1800.00	4100.00	1.00	6.48
	Mean	679012	442.52	472.32	15.10	5.72	441.60	214.14	30.95	39.40	404.21	823.48	0.61	6.17
1996	Std. Dev.	932699	280.08	282.77	12.49	1.67	205.25	63.10	16.68	15.24	371.49	653.88	0.49	0.13
Obs=323	Min	124000	11.18	3.72	0.00	3.50	200.00	80.00	6.00	11.00	0.00	120.00	0.00	5.65
	Max	8100000	981.23	988.32	75.00	16.00	1000.00	400.00	72.00	79.00	1800.00	4500.00	1.00	6.48
	Mean	367169	443.91	467.83	16.39	5.96	443.36	208.57	31.73	40.49	464.83	864.86	0.55	6.16
2009	Std. Dev.	634707	278.42	279.80	13.71	3.22	219.01	61.64	16.95	15.04	500.99	649.24	0.50	0.14
Obs=318	Min	40100	2.52	11.35	0.00	3.50	200.00	80.00	6.00	11.00	0.00	100.00	0.00	5.74
	Max	6440000	981.23	988.77	79.40	35.00	1000.00	400.00	72.00	79.00	3300.00	3200.00	1.00	6.50
Within-two-kilometer zone:														
	Mean	287011	865.75	815.40	10.76	5.65	380.00	199.73	32.76	38.30	625.25	872.75	0.69	6.17
1983	Std. Dev.	346611	505.96	551.38	10.43	1.75	216.06	61.23	18.55	15.20	671.58	669.04	0.46	0.15
Obs=262	Min	41000	1.94	2.81	1.20	1.00	0.00	80.00	4.00	11.00	0.00	0.00	0.00	5.75
	Max	3470000	1945.47	1993.79	60.00	15.00	1000.00	400.00	72.00	79.00	3600.00	3900.00	1.00	6.40
	Mean	1151120	794.18	829.96	15.20	5.73	443.98	207.32	30.01	37.59	417.20	855.85	0.63	6.17
1994	Std. Dev.	2106133	567.59	548.68	13.00	1.72	215.31	57.96	18.75	15.26	389.37	611.57	0.48	0.14
Obs=453	Min	116000	11.18	3.72	0.00	3.50	0.00	80.00	4.00	11.00	0.00	120.00	0.00	5.65
	Max	16000000	1981.76	1984.91	80.00	16.00	1000.00	400.00	143.00	79.00	1800.00	4100.00	1.00	6.48
	Mean	695438	814.19	837.52	14.94	5.71	433.33	208.54	30.14	37.76	460.38	850.92	0.61	6.16
1996	Std. Dev.	1028622	565.70	556.92	12.83	1.65	216.57	59.62	18.52	15.39	425.74	613.61	0.49	0.15
Obs=512	Min	110000	11.18	3.72	0.00	3.50	0.00	80.00	4.00	11.00	0.00	120.00	0.00	5.65
	Max	8320000	1981.76	1984.91	80.00	16.00	1000.00	400.00	143.00	79.00	2300.00	4500.00	1.00	6.48
	Mean	385945	790.65	871.15	16.57	5.86	437.90	203.31	30.89	39.66	498.54	888.85	0.57	6.17
2009	Std. Dev.	763854	556.64	562.96	13.81	2.98	225.81	57.11	17.50	15.55	494.60	620.49	0.49	0.14
Obs=515	Min	40100	2.52	11.35	0.00	3.10	200.00	80.00	4.00	11.00	0.00	100.00	0.00	5.73
	Max	8210000	1981.76	1981.45	80.00	35.00	1000.00	400.00	78.00	79.00	3300.00	3400.00	1.00	6.50

Table 2-1: Estimation results for the within-one-kilometer zone

Year	Distance to the fault line	Distance to the fault line ×Residential use dummy	Width of the front road	Width of the front road ×Residential use dummy	Bulk ratio	Bulk ratio ×Residential use dummy	Time distance to Osaka
1983	-0.000234 (0.000214)	0.000332 (0.000233)	0.001795 (0.006455)	0.064743 (0.014645)***	0.002764 (0.000395)***	-0.002442 (0.000692)***	-0.018128 (0.004662)***
1984	-0.000087 (0.000208)	0.000160 (0.000226)	0.002935 (0.009736)	0.046801 (0.018167)**	0.002656 (0.000387)***	-0.001756 (0.000655)***	-0.016666 (0.004402)***
1985	-0.000024 (0.000208)	0.000122 (0.000225)	-0.006773 (0.009086)	0.046623 (0.017985)**	0.003214 (0.000424)***	-0.002152 (0.000663)***	-0.016940 (0.004560)***
1986	-0.000056 (0.000228)	0.000192 (0.000244)	0.000566 (0.000497)	0.048601 (0.016939)***	0.003456 (0.000460)***	-0.002539 (0.000717)***	-0.018462 (0.004745)***
1987	-0.000176 (0.000277)	0.000253 (0.000289)	0.000064 (0.001046)	0.053089 (0.017250)***	0.004878 (0.000811)***	-0.003764 (0.000970)***	-0.019770 (0.005104)***
1988	-0.000108 (0.000267)	0.000264 (0.000293)	0.000083 (0.000932)	0.074532 (0.022862)***	0.004636 (0.000827)***	-0.004345 (0.001092)***	-0.028178 (0.006035)***
1989	-0.000174 (0.000248)	0.000342 (0.000274)	0.000696 (0.000884)	0.103688 (0.026284)***	0.004424 (0.000759)***	-0.003782 (0.001037)***	-0.025204 (0.004954)***
1990	-0.000018 (0.000235)	0.000163 (0.000262)	-0.000865 (0.000941)	0.093095 (0.023636)***	0.004297 (0.000315)***	-0.003666 (0.000754)***	-0.018671 (0.004354)***
1991	-0.000130 (0.000247)	0.000283 (0.000272)	-0.010463 (0.004709)**	0.088623 (0.021546)***	0.004605 (0.000354)***	-0.003876 (0.000763)***	-0.017848 (0.004432)***
1992	0.000024 (0.000237)	0.000156 (0.000263)	-0.009757 (0.004363)**	0.075329 (0.020618)***	0.004603 (0.000331)***	-0.003609 (0.000714)***	-0.016329 (0.004344)***
1993	0.000183 (0.000180)	-0.000073 (0.000200)	-0.007873 (0.004686)*	0.072459 (0.017036)***	0.004392 (0.000298)***	-0.003007 (0.000605)***	-0.019291 (0.003320)***
1994	0.000235 (0.000172)	-0.000121 (0.000185)	-0.004337 (0.004184)	0.052386 (0.013370)***	0.003918 (0.000277)***	-0.002936 (0.000502)***	-0.020378 (0.002796)***
1995	0.000334 (0.000147)**	-0.000216 (0.000158)	-0.005734 (0.003603)	0.046976 (0.011414)***	0.003771 (0.000234)***	-0.003060 (0.000429)***	-0.015528 (0.002391)***
1996	0.000430 (0.000139)***	-0.000328 (0.000149)**	-0.003200 (0.003559)	0.040670 (0.010317)***	0.003327 (0.000224)***	-0.002646 (0.000397)***	-0.013593 (0.002064)***
1997	0.000453 (0.000126)***	-0.000369 (0.000136)***	-0.002752 (0.003475)	0.020083 (0.007305)***	0.003133 (0.000220)***	-0.002461 (0.000377)***	-0.013809 (0.001789)***
1998	0.000429 (0.000119)***	-0.000327 (0.000130)**	-0.003167 (0.003410)	0.018971 (0.007566)**	0.003033 (0.000216)***	-0.002338 (0.000366)***	-0.013196 (0.001705)***
1999	0.000440 (0.000112)***	-0.000332 (0.000124)***	-0.003503 (0.003330)	0.018577 (0.008000)**	0.003010 (0.000210)***	-0.002307 (0.000365)***	-0.013650 (0.001637)***
2000	0.000462 (0.000102)***	-0.000336 (0.000115)***	-0.003501 (0.002802)	0.013995 (0.006185)**	0.002768 (0.000201)***	-0.002114 (0.000356)***	-0.013215 (0.001588)***
2001	0.000465 (0.000096)***	-0.000344 (0.000111)***	-0.002923 (0.002673)	0.011001 (0.006497)*	0.002553 (0.000203)***	-0.001953 (0.000363)***	-0.013664 (0.001506)***
2002	0.000473 (0.000098)***	-0.000337 (0.000114)***	-0.002759 (0.002668)	0.009504 (0.007069)	0.002407 (0.000215)***	-0.001804 (0.000386)***	-0.014571 (0.001510)***
2003	0.000419 (0.000094)***	-0.000273 (0.000112)**	-0.002138 (0.002436)	0.007734 (0.007419)	0.002361 (0.000210)***	-0.001753 (0.000397)***	-0.014980 (0.001546)***
2004	0.000423 (0.000099)***	-0.000268 (0.000118)**	-0.002448 (0.002553)	0.007043 (0.007957)	0.002316 (0.000224)***	-0.001582 (0.000413)***	-0.016272 (0.001608)***
2005	0.000436 (0.000104)***	-0.000280 (0.000125)**	-0.002931 (0.002668)	0.007667 (0.008506)	0.002318 (0.000235)***	-0.001523 (0.000440)***	-0.017234 (0.001711)***
2006	0.000438 (0.000106)***	-0.000274 (0.000128)**	-0.003297 (0.002815)	0.008380 (0.008922)	0.002438 (0.000245)***	-0.001625 (0.000460)***	-0.018233 (0.001876)***
2007	0.000444 (0.000122)***	-0.000264 (0.000144)*	-0.004252 (0.003125)	0.006213 (0.008958)	0.002726 (0.000260)***	-0.002016 (0.000487)***	-0.020685 (0.002010)***
2008	0.000450 (0.000129)***	-0.000265 (0.000152)*	-0.004915 (0.003350)	0.007117 (0.008777)	0.002963 (0.000275)***	-0.002348 (0.000519)***	-0.022015 (0.002109)***
2009	0.000462 (0.000125)***	-0.000317 (0.000150)**	-0.003754 (0.003337)	0.005882 (0.007968)	0.002853 (0.000276)***	-0.002427 (0.000541)***	-0.021223 (0.002089)***

Year	Time distance to Osaka ×Residential use dummy	Distance to nearest station	Distance to nearest station ×Residential use dummy	Residential use dummy	Natually-logarithmic Average household income	Number of obs	R-squared
1983	-0.000119 (0.005099)	-0.000357 (0.000119)***	0.000109 (0.000131)	-0.163458 (0.353612)	0.141102 (0.193788)	165	0.81
1984	-0.001178 (0.004867)	-0.000436 (0.000127)***	0.000235 (0.000137)*	-0.200427 (0.348343)	0.305268 (0.202839)	168	0.80
1985	-0.001274 (0.005029)	-0.000434 (0.000138)***	0.000207 (0.000149)	-0.057564 (0.348997)	0.357548 (0.201726)*	167	0.80
1986	-0.000086 (0.005232)	-0.000368 (0.000157)**	0.000133 (0.000166)	-0.010694 (0.371403)	0.350383 (0.197285)*	160	0.81
1987	0.001244 (0.005536)	-0.000298 (0.000150)**	0.000059 (0.000159)	0.183629 (0.512518)	0.470819 (0.216606)**	160	0.83
1988	0.003551 (0.006806)	-0.000419 (0.000148)***	0.000126 (0.000162)	0.088436 (0.591987)	0.397168 (0.267962)	158	0.81
1989	0.003310 (0.005806)	-0.000608 (0.000150)***	0.000271 (0.000164)*	-0.281468 (0.578637)	0.393191 (0.272514)	162	0.82
1990	0.004125 (0.005246)	-0.000670 (0.000128)***	0.000357 (0.000142)**	-0.394246 (0.408491)	0.397534 (0.266550)	181	0.87
1991	0.001936 (0.005317)	-0.000728 (0.000126)***	0.000397 (0.000143)***	-0.380685 (0.394141)	0.449394 (0.261066)*	178	0.87
1992	0.000338 (0.005200)	-0.000865 (0.000157)***	0.000575 (0.000169)***	-0.326724 (0.387880)	0.112922 (0.269442)	188	0.89
1993	0.001314 (0.003853)	-0.000765 (0.000139)***	0.000506 (0.000150)***	-0.276441 (0.302390)	0.201372 (0.243738)	247	0.89
1994	0.001919 (0.003176)	-0.000528 (0.000164)***	0.000320 (0.000171)*	-0.090715 (0.240477)	0.334039 (0.198833)*	293	0.89
1995	-0.002597 (0.002742)	-0.000483 (0.000130)***	0.000314 (0.000135)**	0.297080 (0.200126)	0.286424 (0.170401)*	324	0.88
1996	-0.003750 (0.002406)	-0.000413 (0.000123)***	0.000239 (0.000128)*	0.452361 (0.185296)**	0.181758 (0.153870)	323	0.87
1997	-0.003777 (0.002134)*	-0.000307 (0.000096)***	0.000138 (0.000102)	0.632138 (0.168450)***	0.168468 (0.145526)	334	0.87
1998	-0.003892 (0.002056)*	-0.000295 (0.000091)***	0.000121 (0.000097)	0.632083 (0.163221)***	0.191126 (0.140066)	338	0.87
1999	-0.004565 (0.002005)**	-0.000279 (0.000089)***	0.000100 (0.000095)	0.692545 (0.160573)***	0.135860 (0.140245)	344	0.87
2000	-0.005922 (0.001972)***	-0.000326 (0.000073)***	0.000144 (0.000080)*	0.739826 (0.153898)***	0.108546 (0.133510)	347	0.87
2001	-0.006202 (0.001927)***	-0.000311 (0.000071)***	0.000124 (0.000078)	0.774585 (0.158654)***	0.123205 (0.126423)	349	0.86
2002	-0.006826 (0.001961)***	-0.000306 (0.000072)***	0.000116 (0.000079)	0.803184 (0.170317)***	0.105670 (0.130637)	351	0.85
2003	-0.007488 (0.002000)***	-0.000327 (0.000059)***	0.000131 (0.000068)*	0.814705 (0.178706)***	0.125080 (0.130294)	375	0.85
2004	-0.007218 (0.002068)***	-0.000324 (0.000061)***	0.000125 (0.000071)*	0.792339 (0.187683)***	0.163950 (0.132893)	376	0.84
2005	-0.006753 (0.002206)***	-0.000328 (0.000063)***	0.000126 (0.000073)*	0.772837 (0.200210)***	0.166527 (0.138191)	372	0.83
2006	-0.006402 (0.002391)***	-0.000327 (0.000063)***	0.000120 (0.000074)	0.780649 (0.210004)***	0.196565 (0.143778)	372	0.83
2007	-0.005241 (0.002582)**	-0.000321 (0.000064)***	0.000079 (0.000076)	0.856250 (0.226074)***	0.280260 (0.161118)*	349	0.84
2008	-0.003579 (0.002705)	-0.000324 (0.000068)***	0.000064 (0.000080)	0.861912 (0.237168)***	0.336597 (0.172099)*	340	0.85
2009	-0.004324 (0.002722)	-0.000336 (0.000067)***	0.000089 (0.000080)	0.922408 (0.239139)***	0.218402 (0.171005)	318	0.85

Note: The values in parentheses are robust standard errors. Asterisks *, **, and *** denote the level of significance at the 0.10, 0.05, and 0.01 levels, respectively.

Table 2-2: Estimation results for the within-two-kilometer zone

Year	Distance to the fault line	Distance to the fault line ×Residential use dummy	Number of obs	R-squared
1983	-0.000098 (0.000095)	0.000093 (0.000105)	262	0.82
1984	-0.000070 (0.000079)	0.000061 (0.000089)	260	0.83
1985	-0.000022 (0.000075)	0.000020 (0.000085)	263	0.83
1986	-0.000087 (0.000080)	0.000082 (0.000089)	253	0.84
1987	-0.000069 (0.000086)	0.000037 (0.000093)	255	0.86
1988	0.000011 (0.000086)	-0.000055 (0.000100)	256	0.83
1989	-0.000011 (0.000089)	-0.000021 (0.000100)	267	0.83
1990	-0.000074 (0.000073)	0.000027 (0.000085)	295	0.88
1991	-0.000105 (0.000073)	0.000052 (0.000085)	293	0.88
1992	-0.000076 (0.000070)	0.000024 (0.000082)	301	0.89
1993	-0.000013 (0.000060)	-0.000041 (0.000067)	387	0.90
1994	0.000029 (0.000065)	-0.000060 (0.000069)	453	0.89
1995	0.000062 (0.000054)	-0.000089 (0.000058)	514	0.88
1996	0.000104 (0.000051)**	-0.000121 (0.000055)**	512	0.87
1997	0.000108 (0.000047)**	-0.000131 (0.000051)**	537	0.87
1998	0.000107 (0.000046)**	-0.000128 (0.000050)***	543	0.86
1999	0.000106 (0.000046)**	-0.000123 (0.000050)**	550	0.86
2000	0.000115 (0.000044)***	-0.000127 (0.000048)***	554	0.85
2001	0.000117 (0.000042)***	-0.000132 (0.000047)***	556	0.84
2002	0.000131 (0.000043)***	-0.000138 (0.000048)***	558	0.83
2003	0.000126 (0.000041)***	-0.000139 (0.000047)***	599	0.83
2004	0.000140 (0.000043)***	-0.000152 (0.000049)***	600	0.82
2005	0.000112 (0.000038)***	-0.000130 (0.000046)***	590	0.83
2006	0.000117 (0.000039)***	-0.000142 (0.000047)***	591	0.83
2007	0.000118 (0.000043)***	-0.000139 (0.000052)***	556	0.84
2008	0.000132 (0.000045)***	-0.000152 (0.000054)***	543	0.84
2009	0.000134 (0.000046)***	-0.000153 (0.000054)***	515	0.85

Note: The estimated coefficients on explanatory variables other than the distance to the fault line are not reported. The values in parentheses are robust standard errors. Asterisks *, **, and *** denote the level of significance at the 0.10, 0.05, and 0.01 levels, respectively.

Table 3-1: Estimation results using only points continuously appraised between 1993 and 2009 for the within-one- and within-two-kilometer zones

Panel A: Within-one-kilometer

Year	Distance to the fault line	Distance to the fault line ×Residential use dummy	Number of obs	R-squared
1993	0.000289 (0.000215)	-0.000143 (0.000238)	175	0.90
1994	0.000281 (0.000205)	-0.000134 (0.000223)	175	0.90
1995	0.000303 (0.000182)*	-0.000157 (0.000198)	175	0.90
1996	0.000346 (0.000163)**	-0.000211 (0.000176)	175	0.89
1997	0.000399 (0.000155)**	-0.000258 (0.000168)	175	0.89
1998	0.000384 (0.000148)**	-0.000243 (0.000161)	175	0.89
1999	0.000402 (0.000144)***	-0.000247 (0.000158)	175	0.88
2000	0.000438 (0.000136)***	-0.000278 (0.000151)*	175	0.88
2001	0.000453 (0.000133)***	-0.000289 (0.000150)*	175	0.87
2002	0.000469 (0.000136)***	-0.000293 (0.000154)*	175	0.86
2003	0.000477 (0.000142)***	-0.000291 (0.000162)*	175	0.85
2004	0.000490 (0.000148)***	-0.000292 (0.000170)*	175	0.85
2005	0.000507 (0.000154)***	-0.000303 (0.000177)*	175	0.84
2006	0.000508 (0.000162)***	-0.000300 (0.000185)	175	0.84
2007	0.000480 (0.000175)***	-0.000269 (0.000197)	175	0.85
2008	0.000488 (0.000186)***	-0.000277 (0.000208)	175	0.85
2009	0.000492 (0.000182)***	-0.000284 (0.000204)	175	0.85

Panel B: Within-two-kilometer

Year	Distance to the fault line	Distance to the fault line ×Residential use dummy	Number of obs	R-squared
1993	0.000070 (0.000068)	-0.000070 (0.000076)	274	0.90
1994	0.000065 (0.000062)	-0.000059 (0.000070)	274	0.91
1995	0.000085 (0.000054)	-0.000069 (0.000062)	274	0.90
1996	0.000091 (0.000051)*	-0.000066 (0.000059)	274	0.90
1997	0.000099 (0.000051)*	-0.000073 (0.000058)	274	0.89
1998	0.000096 (0.000050)*	-0.000069 (0.000057)	274	0.89
1999	0.000103 (0.000051)**	-0.000070 (0.000058)	274	0.88
2000	0.000112 (0.000050)**	-0.000073 (0.000058)	274	0.87
2001	0.000118 (0.000051)**	-0.000076 (0.000059)	274	0.86
2002	0.000128 (0.000052)**	-0.000078 (0.000061)	274	0.85
2003	0.000139 (0.000053)***	-0.000086 (0.000062)	274	0.84
2004	0.000155 (0.000055)***	-0.000099 (0.000065)	274	0.83
2005	0.000167 (0.000056)***	-0.000114 (0.000067)*	274	0.83
2006	0.000172 (0.000059)***	-0.000123 (0.000069)*	274	0.83
2007	0.000167 (0.000063)***	-0.000120 (0.000073)	274	0.84
2008	0.000175 (0.000066)***	-0.000130 (0.000077)*	274	0.84
2009	0.000173 (0.000066)***	-0.000131 (0.000076)*	274	0.84

Note: The estimated coefficients on explanatory variables other than the distance to the fault line are not reported. The values in parentheses are robust standard errors. Asterisks *, **, and *** denote the level of significance at the 0.10, 0.05, and 0.01 levels, respectively.

.

Table 3-2: Estimation results using only points continuously appraised between 1993 and 1997 for the within-one- and within-two-kilometer zones

Panel A: Within-one-kilometer

Year	Distance to the fault line	Distance to the fault line ×Residential use dummy	Number of obs	R-squared
1993	0.000224 (0.000185)	-0.000094 (0.000207)	228	0.89
1994	0.000234 (0.000175)	-0.000095 (0.000193)	228	0.90
1995	0.000277 (0.000155)*	-0.000140 (0.000170)	228	0.89
1996	0.000342 (0.000138)**	-0.000222 (0.000152)	228	0.89
1997	0.000393 (0.000129)***	-0.000267 (0.000143)*	228	0.89

Panel B: Within-two-kilometer

Year	Distance to the fault line	Distance to the fault line ×Residential use dummy	Number of obs	R-squared
1993	0.000011 (0.000061)	-0.000059 (0.000068)	359	0.90
1994	0.000007 (0.000055)	-0.000040 (0.000062)	359	0.90
1995	0.000028 (0.000048)	-0.000044 (0.000054)	359	0.90
1996	0.000044 (0.000045)	-0.000049 (0.000051)	359	0.89
1997	0.000053 (0.000044)	-0.000053 (0.000050)	359	0.88

Note: The estimated coefficients on explanatory variables other than the distance to the fault line are not reported. The values in parentheses are robust standard errors. Asterisks *, **, and *** denote the level of significance at the 0.10, 0.05, and 0.01 levels, respectively.

Table 4: Test statistics of the constancy of the nonparametric part using semiparametric estimation for the within-one-kilometer zone

Year	P-value	Number of obs	R-squared
1983	0.157	164	0.82
1984	0.416	167	0.81
1985	0.363	166	0.81
1986	0.709	159	0.81
1987	0.298	159	0.84
1988	0.791	157	0.81
1989	0.971	161	0.80
1990	0.728	180	0.87
1991	0.720	177	0.88
1992	0.575	187	0.88
1993	0.369	246	0.90
1994	0.157	292	0.89
1995	0.069	323	0.89
1996	0.015	322	0.88
1997	0.001	333	0.88
1998	0.002	337	0.88
1999	0.003	343	0.87
2000	0.001	346	0.87
2001	0.000	348	0.86
2002	0.001	350	0.85
2003	0.014	374	0.84
2004	0.012	375	0.84
2005	0.020	371	0.83
2006	0.029	371	0.83
2007	0.031	348	0.84
2008	0.030	339	0.84
2009	0.040	317	0.85

Note: The reported p-value is for the test statistic for the null hypothesis of the constancy of the nonparametric part.

Figure 1: The location of the Uemachi and Rokko–Awaji fault lines with data points of observation in the *Published Land Prices*

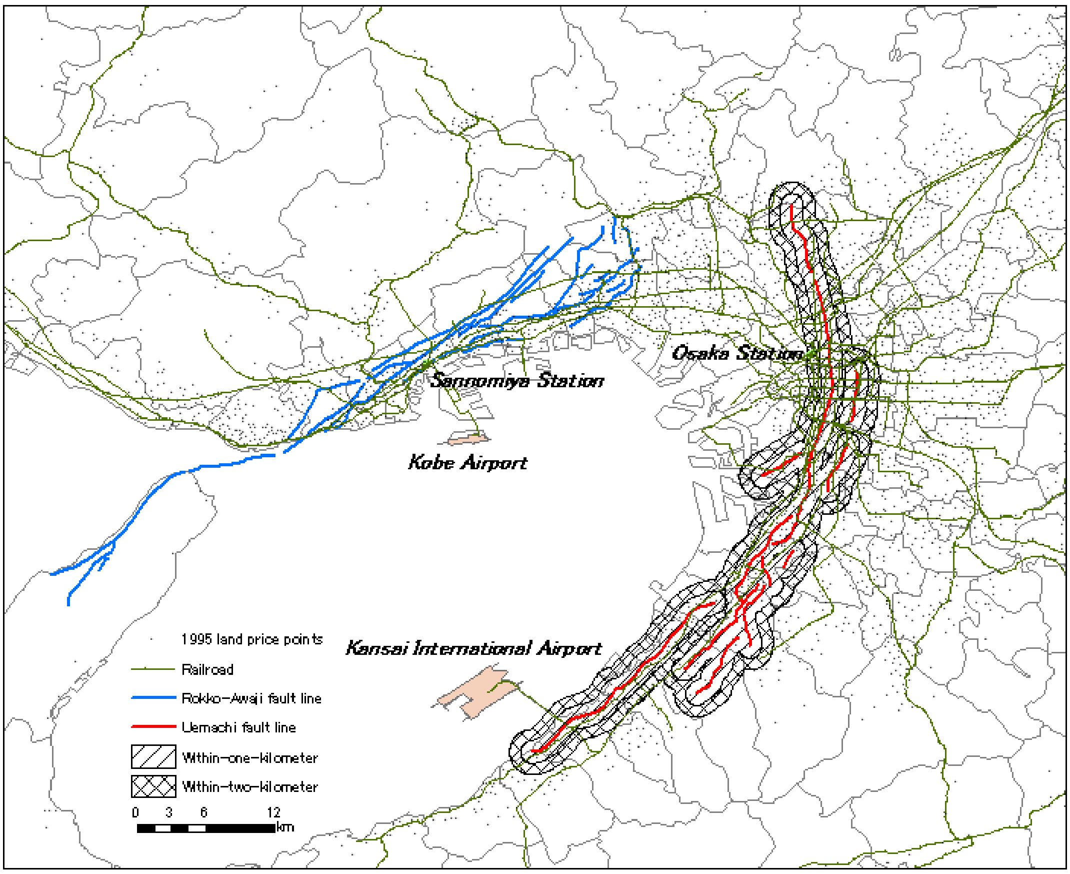

Figure 2: The time series of the estimated coefficient
for the distance to the fault line with 95 percent confidence intervals
for nonresidential areas within one kilometer on both sides of the fault line

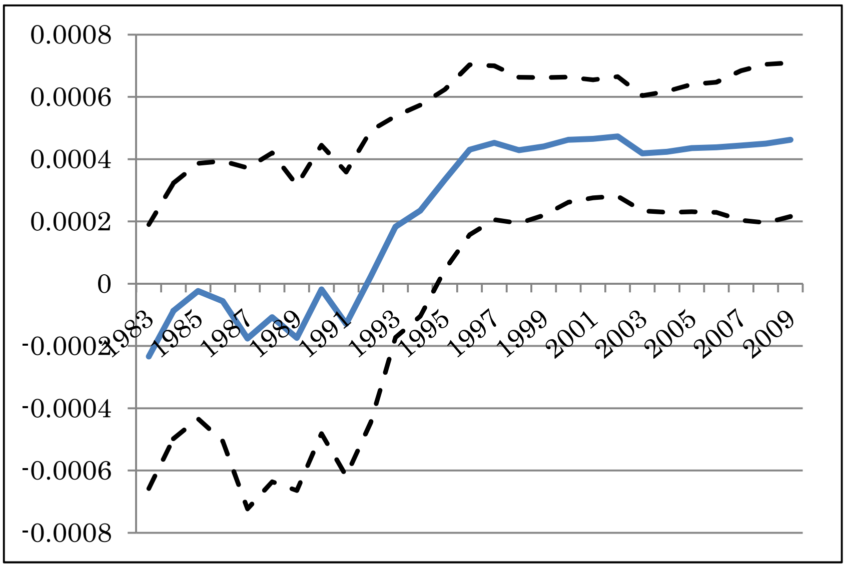

Figure 3: A comparison of the semiparametric estimation and linear specification
for the 1996 sample