Transparency and View Regarding Nuclear Energy Before and After the Fukushima Accident: Evidence on Micro-data

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Abstract

This paper examines the influence of government transparency on changing views regarding nuclear energy before and after Japan's natural and nuclear disaster of 2011. Individual level data were used, covering 45 countries and containing 27,423 observations. It was observed in the majority of countries that the rate of favoring nuclear energy declined after the disaster. However, empirical results show that such a tendency is less likely to be observed in a more transparent country. This implies that views regarding nuclear energy were less elastic to the news of the Fukushima incident when people were more certain about nuclear energy prior to the Fukushima incident.

JEL classification: D73, D82, H12, Q54

Key words: Nuclear energy, persuasion, information, transparency, learning, Fukushima accident.

1. Introduction

On March 11, 2011, one of the worst natural disasters in modern times hit Japan—a devastating earthquake accompanied by a tsunami. As a consequence, a number of serious accidents occurred at the Fukushima Daiichi nuclear power plant, resulting in nuclear leakage. This combination of disasters caused tremendous damage to the Japanese economy. Furthermore, economic globalization meant that the effects of the disaster were felt worldwide. In terms of the political consequences, approximately two weeks after the disaster, with nuclear energy becoming a hotly debated international topic, a German political party that opposed nuclear energy won their state election (Baden-Wurttemberg state). This result would indicate that Japan's nuclear disaster has influenced views regarding nuclear energy in countries some distance from Japan.

A growing number of researchers are investigating the outcomes of natural disasters (e.g., Skidmore and Toya 2002; Toya and Skidmore 2007; Yamamura 2010). Existing literature has shown that democratic nations and those with effective governments suffer less damage from natural disasters compared with other countries. (Kahn 2005; Escaleras et al., 2007). Eisensee and Stromberg (2007) have stated that information obtained through the news media can play a critical role in disaster relief. Berger (2010) found that in Germany, nuclear incidents such as Chernobyl can increase an individual's concern for the environment. Both democratic institutions and the mass media play lead roles in ensuring that the preferences of citizens are reflected in policy (Besley and Burgess 2002).[1] Education and media played significant roles in forming citizens' views regarding the events of September 11, 2001 (Gentzkow and Shapiro 2004). The quality and quantity of information regarding nuclear energy was important in forming views about nuclear energy after the incident on March 11, 2011. Yamamura (2012) examined the role of media and its effect on the perceived safety of nuclear energy after the Fukushima accident.

Aside from private mass-media firms, the present paper also focuses on the role of

[1] Government transparency contributes to increasing economic efficiency (Alt and Lassen 2006; Bruns and Himmler 2011).

government in providing sufficient information regarding nuclear energy to enable the public to form opinions. The Fukushima incident is considered to be a natural experiment to examine how an unpredicted event can change the views of citizens and the extent to which that influence depends on institution. The persuasion approach offers a useful framework with which to consider the role of government in providing information about nuclear energy (DellaVigna and Gentzkow 2010). According to the belief-based model of persuasion (DellaVigna and Gentzkow 2010), people would be less likely to be affected by news of the Fukushima incident if government had already provided sufficient information regarding nuclear energy. Islam (2006) developed an indicator that measures the frequency with which governments update data to be released to the public. The indicator is considered to represent government transparency (Islam 2006). Individual level data regarding views on nuclear energy before and after the Fukushima incident in each county were sourced from WIN-Gallup International. This paper used the data, which consist of 27,423 observations, to investigate the effect of prior information provided by government on any changes in the views of citizens regarding nuclear energy before and after the Fukushima incident. The key finding is that people were less likely to be affected by the Fukushima incident if they had received more frequent government updates, although the share of people favoring nuclear energy declined after the disaster in the majority of countries.

The remainder of the paper is structured as follows: Section 2 outlines the simple empirical model and the study's hypotheses are proposed. Data and regression equations are presented in Section 3. Section 4 provides the estimation results and their interpretation. Section 5 concludes.

2. Simple Model and Hypothesis

To describe the empirical model in a simplistic form, I used a persuasion model framework. As shown by DellaVigna and Gentzkow (2010), persuasion models are generally divided into two categories: belief-based models (Stigler 1961, Telser 1964) and preference-based models (Stigler and Becker 1977; Becker and Murphy 1993). In a belief-based model, which is largely based on

Bayesian theory, the weaker the priors of the individuals who receive additional information, the greater the influence that the information will have on their beliefs. To put it differently, new information has a weak influence on the attitudes and behaviors of individuals who are close to certain about the state ex ante.

The effects of receiving prior information are often examined in the domain of political persuasion (Prior 2006; Enikolopov et al. 2009). On this topic, Zaller (1992) found that the Iran-Contra affair did not change individuals' views regarding Ronald Reagan, partly because individuals had prior knowledge of his performance. The frequency with which governments update data to be released to the public can be considered the degree of prior knowledge regarding nuclear energy. When the Fukushima incident occurred, citizens received new information regarding nuclear energy via various media sources, such as the Internet. The use of a belief-based framework model would be appropriate to analyze the subject matter of this study. Hence, in a manner similar to previous works of political persuasion, this paper attempts to explore the impact of the Fukushima incident on the views of individuals regarding nuclear energy. A simple empirical model would assume:

$$\text{VIEW}(0) = \alpha_0 + \alpha_1\,\text{NETBEN}(0) + e, \qquad (1)$$

where VIEW(0) are those favoring nuclear power after the incident and NETBEN(0) is the perceived net benefits of nuclear power after the incident. The variable NETBEN(0) also incorporates the perceived risk of a nuclear accident. The error term is denoted by e. We would expect $\alpha_1 > 0$, i.e., higher perceived net-benefits imply that more people favor nuclear power. In addition:

$$\text{NETBEN}(0) = \text{NETBEN}(-1) + \text{DNETBEN}, \qquad (2)$$

where NETBEN(–1) is the perceived net-benefits prior to the incident and dnetben is the perceived change in netben after the incident, i.e., DNETBEN = NETBEN(0) – NETBEN(–1). Note that the variables NETBEN(I) and DNETBEN are unobservable. We can use VIEW(–1) as a proxy for NETBEN(–1) under the assumption that:

$$NETBEN(-1) = \beta_0 + \beta_1 VIEW(-1) + u, \qquad (3)$$

where $\beta_1 > 0$. The error term is denoted by u. Furthermore, under additional informational assumptions discussed below, we can also assume that TRANS, which captures the degree of government transparency, affects DNETBEN:

$$DNETBEN = \eta_0 + \eta_1 TRANS + w. \qquad (4)$$

As will be discussed below, it is unclear what sign to expect for η_1. w is error term. However, substituting (2)–(4) into (1) and subtracting VIEW (–1) on both sides, we get our estimated equation:

$$VIEW(0) - VIEW(-1) = \alpha_0 + \alpha_1\beta_1 + \eta_0 + (\alpha_1\beta_1 - 1)VIEW(-1) + \eta_1 \, TRANS + \alpha_1 u + w. \qquad (5)$$

To obtain consistent estimates, however, w and u should be uncorrelated with the explanatory variables used in (5).

This equation can be rewritten as the following equation (6):

$$VIEW(0) - VIEW(-1) = \gamma_0 + \gamma_1 VIEW(-1) + \gamma_2 \, TRANS + r. \qquad (6)$$

The error term is denoted by r. In addition to the assumptions ($\alpha_1 > 0$, $\beta_1 > 0$) previously mentioned, if magnitudes of α_1 and β_1 are sufficiently large, then $\alpha_1\beta_1 > 1$. This leads me to expect that the sign of γ_1 is positive in equation (6). In contrast, if magnitudes ofα_1 and β_1 are not sufficiently large, then $\alpha_1\beta_1 < 1$. Hence, it is expected that the sign of γ_1 is negative in equation (6). The empirical question here is whether the sign of γ_1 becomes positive or negative.

As previously mentioned, I believe that we can learn more about (4) and (5) by adding further informational structure to the model. To illustrate, let Q be a variable on the [0,1]-interval representing the degree of transparency, where $Q = 1$ is fully transparent and $Q = 0$ is entirely non-transparent (e.g., North Korea). Then, Q can be interpreted as the amount of information that passes through to the public. Moreover, let C^* be the expected costs of nuclear power under full information (in the following, we ignore benefits that we assume will not be affected by the disaster). Peoples' perceptions of the cost prior to the tsunami could then be represented as:

$$C(-1) = Q\, C^*. \qquad (7)$$

Thus, entirely transparent countries ($Q = 1$) correctly perceive $C(-1) = C^*$, whereas non-transparent countries ($Q = 0$) perceive $C(-1) = 0$. Next, we consider what happens after the disaster, distinguishing between three cases.

CASE 1: All information is revealed

This case assumes that the "full information" cost, C^*, does not change after the disaster. However, it is assumed that the public in all countries can now observe the actual potential costs of nuclear power. That is, regardless of transparency, people can obtain accurate information regarding the nuclear incident after the incident occurs. The emergence and development of cross-border media enable people to obtain the information, even in less transparent countries. The supply of information regarding nuclear energy is drastically increased when the incident takes place. Hence, the amount of information obtained by people via the media, for example, using the Internet, is greater after the incident than before. Hence, before the accident, the information obtained is considered to largely depend on the degree of transparency. This assumption is considered to reflect the real situation in 2011, where the Internet is widely available worldwide.

$$C(0) - C(-1) = C^* - Q\, C^* = C^*\, (1-Q).$$

Notice that the perceived costs increase in all countries (except those that are fully transparent), but more so in the non-transparent countries. Thus, the change in the perceived costs of nuclear power is negatively related to transparency. In terms of equations (4) and (5), this implies that $\eta_1>0$ and $\gamma_2>0$. From this, I propose Hypothesis 1.

Hypothesis 1:

Attitudes toward nuclear energy change less in more transparent countries even after the occurrence of a nuclear accident.

CASE 2: Shock to cost and imperfect pass-through

This case assumes that the disaster resulted in a general shock, w, to the “full information” cost of nuclear power, i.e., costs increase to C* + w. However, a lack of transparency implies that this is not fully revealed in all countries. In contrast to CASE 1, cross-border media have not been well developed and people are unable to obtain information via cross-border media. Therefore, transparency of country is considered to influence the circulation of information after the incident occurs. Thus:

$$C(0) – C(–1) = Q (C^* + w) – Q C^* = Q w.$$

This means that perceived costs increase in all countries, but in contrast to CASE 1 the change is greater in more transparent societies. Thus, the change in the perceived costs of nuclear power is positively related to transparency. In terms of equations (4) and (5), this implies that $\eta_1<0$ and $\gamma_2<0$. Thus, Hypothesis 2 is postulated as follows:

Hypothesis 2:

Attitudes toward nuclear energy change more in more transparent countries after the occurrence of a nuclear accident.

CASE 3: Shock to cost and perfect pass-through of shock

This case is similar to CASE 2, but it is now assumed that the shock—and only the shock—is fully observed in all countries. In this situation, cross-border media have not been sufficiently developed, nor are they widespread, although some media are present. Hence, people do receive information regarding the shock, but not regarding nuclear energy.

$C(0) - C(-1) = Q\,C^* + w - Q\,C^* = w.$

Now the perceived cost increases in all countries by the same amount, w. Moreover, transparency has no effect on the change, i.e., $\eta_1 = \gamma_2 = 0$. This leads to Hypothesis 3.

Hypothesis 3:

Attitudes toward nuclear energy are not affected by transparency even after the occurrence of a nuclear accident.

3. Data and Specification

In March 2011, approximately two weeks after Japan's natural disaster, WIN-Gallup International (2011) conducted a survey regarding nuclear energy in 47 countries[2]. The Inter-University Consortium for Political and Social Research (ICPSR) provided the individual level data used in the analysis in this paper; 27,423 samples were used for the baseline estimations.

[2] Serbia and Palestine are included in the survey; however, they are not included in the data used in this paper because of a lack of macro economic variables and the transparency index used in this paper. Thus, the number of countries is reduced from 47 to 45.

The survey contained the following questions: "What was your view about nuclear energy prior to the Japan earthquake?" and "What was your view about nuclear energy after the Japan earthquake?" Respondents were given four response options: “strongly favor”, “somewhat favor”, “somewhat oppose”, or “strongly oppose”. I merged the four groups into two groups: “favor” and “oppose”[3] and calculated any changes in the rate of favoring nuclear energy. These results are presented in column (1), Table 1. With the exception of Azerbaijan, Fiji, Morocco, South Africa, and Spain, the rates of favoring nuclear energy are represented by a negative value for the surveyed countries. These results suggest that the nuclear accident in Japan has made people more cautious about nuclear energy. Thus, the accident has had an obvious impact on views regarding nuclear energy worldwide. Respondents may, however, not accurately recall what their views on the matter were prior to the incident. Furthermore, their post-earthquake views may have been only temporarily affected. These possibilities can result in measurement errors, causing a bias known as attenuation bias. This generally results in the downward bias of estimates[4]. Individual values of VIEW(0) and VIEW(–1) range between 1 (strongly oppose) and 4 (strongly favor). As shown in Table 2, mean values for VIEW(0) and VIEW(–1) are 2.72 and 2.56, respectively. Their standard deviations are both 1.06, which is not considered large. However, the mean of DVIEW is –0.15, with a standard deviation of 0.74. The standard deviation for DIVIEW is regarded as remarkably large, suggesting a measurement error as mentioned above. Therefore, what I estimated in the presence of the measurement error is in fact less in magnitude than the true effect. That is, attenuation bias possibly occurs in the estimations. If the measurement errors do not vary systematically across the countries, then the measurement error does not necessary pose a great problem.

Even if the measurement error is not great problem, a potential problem with the survey design requires a stability check via a comparison with other surveys on nuclear power. GlobeScan

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3 The aggregated level results regarding the favoring of nuclear energy before and after the natural disaster in each county are available from WIN-Gallup International (2011). It is available at http://www.nrc.co.jp/report/pdf/110420_2.pdf (accessed 29 April 2011).

4 There may also be other biases present. For instance, if there is a temporary downward shift in preferences and attitudes that eventually return to their original level, then the effect is overestimated and at best only captures the short-term effect. The estimates may be biased for this reason. Controlling for this bias is beyond the scope of this paper. Thus, special care should be called for when interpreting the estimation results.

conducted polls concerning nuclear energy in 2005 and between June and September in 2011. Respondents were asked whether or not they supported the opinion “Nuclear power is relatively safe and an important source of electricity. We should build new plants”. Data are available regarding the share of respondents who supported this opinion in each year and the difference between 2005 and 2011[5]. This information does not suffer from the bias discussed above. The GlobeScan survey has been conducted in eight countries (France, Germany, Indonesia, Japan, Mexico, Russia, the United Kingdom, and the United States). WIN-Gallup International has also conducted surveys in six of those countries.

In column (2), Table 1, the difference in the share is reported for 6 countries: France, Germany, India, Japan, Russia, and the United States. Negative values are observed for all countries, which is in line with column (1) showing data from WIN-Gallup International[6]. A closer examination provides a more interesting finding: France has absolute values of 8 in column (1) and 10 in column (2) and the values for India are 9 in column (1) and 10 in column (2). Thus, the difference of the values between the two surveys is 2 and 1 for France and India, respectively. This indicates that the results based on the WIN-Gallup International and GlobeScan surveys are similar. Therefore, the bias caused by the survey design is not observed for France and India. In contrast, Japan has absolute values of 23 in column (1) and 15 in column (2) and for Russia these are 11 in column (1) and 3 in column (2). The values for the United States are 6 in column (1) and 1 in column (2). These results show that changes of opinions regarding nuclear energy before and after the Fukushima accident are much larger in the data from the WIN-Gallup International than the data from GlobeScan. This suggests that the measurement error is large for Japan, Russia and the United States. These countries all experienced serious nuclear accidents: Fukushima, Chernobyl and Three Mile Island. Respondents from Japan were survey by WIN-Gallup International immediately after the Fukushima accident, which naturally influenced their responses. As for Russia and the United

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[5] Data available at http://www.globescan.com/images/images/pressreleases/bbc2011_nuclear_energy/bbc2011_energy.pdf. (Accessed April 5, 2013).

[6] Among the eight countries survey by GlobeScan, a positive value was only observed for the United Kingdom; however, it is not reported in Table 1 because the WIN-Gallup survey was not conducted in the United Kingdom.

States, memories of their respective accidents seem to have caused anxiety and concern among respondents and their responses reflect a strong reaction to the Fukushima accident[7].

The frequency with which government-update data are available to the public is used to represent government transparency (Islam 2006). Therefore, government transparency plays a significant role in forming the prior knowledge of citizens. For the 11 representative economic variables, Islam (2006) observed the actual frequency level with which the data are published to create the index of government transparency. This index is used as the proxy variable for the degree of government transparency, TRANS, which appears earlier in the paper in equations (4) and (5) (section 2, p. 6). However, non-economic factors are not taken into account in creating the index because the index is calculated using economic variables. Thus, non-economic factors, such as political issues and whether a Freedom of Information Act (FOI) has been adopted, should be also considered when creating the index. That is, "the transparency index indicates how much economic information governments are willing to disclose—but the FOI law gives access to more than just economic data" (Islam 2006, 131). To this end, Islam (2006) constructed an alternative measure of government transparency, TRANS1 and TRANS2. TRANS1 combines TRANS and a dummy for the adoption of the FOI. The degree to which the FOI takes root is thought to have different effects and depends on the number of years that have passed since it was adopted. Therefore, TRANS2 combines TRANS and the index of years that have passed since the FOI was adopted. As a robustness check on the impact of government transparency (considered as an effect of citizens' prior knowledge), this paper uses TRANS, TRANS1, and TRANS2 as proxies for government transparency.

Definitions and the basic statistics for the variables used in the estimations are presented in Table 2. The estimated function takes the following form:

$DVIEW_{ij} = \gamma_0 + \gamma_1 TRANS_i\ (TRANS_i1 \text{ or } TRANS_i2) + \gamma_2 VIEW(-1)_i + \gamma_3 EXPE_i + \gamma_4 CORRUPT_i + \gamma_5 CATHO_i + \gamma_6 LEGAL\_EN_i + \gamma_7\ LEGAL\_FR_i + \gamma_8 NCLEAR_i + \gamma_9 Ln(POP)_i + \gamma_{10} GDP_i +$

[7] Absolute values for Germany are 8 in column (1) and 15 in column (2), which are in contrast to the results of Japan, Russia, and the United States.

$\gamma_{11}GOVSIZ_i + \gamma_{12}EASIA_i + \gamma_{13}EUROP_i + \gamma_{14}NDIS_i + X_{ij}\theta + u_i$,

where DVIEW represents a change in degree of favoring nuclear energy before and after the natural disaster for individual j in country i, α represents regression parameters, and u is the error term. In addition, X represents the vector of the individual characteristics (age, household income dummies, level of education dummies, job status dummies, gender dummies, and residential place dummies) of the respondent and $\theta$is the vector of its regression parameters. As shown in Table 2, level of household income is measured by a subjective evaluation and not an objective one because an objective measure is not available from the data (although an objective measure is more desirable).

Table 2 also shows the share of each group for each variable as follows: share of those who regarded their household income as low (20%, which is the similar to share of those who regarded their household income as medium low and medium) and share of those who regarded their household income as medium high (14%, which is the same as the share of those who regarded their household income as high). Hence, no income group in particular enjoyed a greater share. Concerning education level, I was only able to obtain rough categories: (1) no education or basic education, (2) secondary school, and (3) a high level of education such as university. The percentages of no education or basic education, secondary school, and high level are 25, 43, and 32%, respectively. Job status can be categorized into 4 groups: (1) retired, (2) full-time worker, (3) unemployed, and (4) housewife or student (the largest percentage is that held by full-time worker at 54%). The percentage of female respondents at 49% is almost the same as that of males at 51%. Residential address is categorized as either urban or rural residents. The percentage of urban residents is 72%, suggesting that the majority of respondents reside in urban areas.

The view of nuclear energy before the natural disaster has been included (VIEW(–1)) to control for the initial level of favoring nuclear energy. People in countries that have experienced a devastating nuclear disaster may be more concerned than those in other countries. Hence, it may be appropriate to control for countries such as Russia and the United States (which experienced the Chernobyl and Three Mile Island accidents) to attenuate the bias discussed in the previous section.

To this end, I incorporate EXPE, which is a dummy variable for Russia and the United States. In addition to TRANS, various institutional factors possibly influence people's perceptions (Sobel, 2002; MacCulloch and Pezzini, 2010). For instance, a corrupt government may hide important information for the benefit of bureaucrats and politicians at the expense of the rest of society. Inevitably, the degree of government corruption influences perceptions (Yamamura, 2011). In addition, religion was found to be associated with people's perceptions in modern economic research (e.g., Guiso et al., 2003; Arrunada, 2010; MacCulloch and Pezzini, 2010). Furthermore, it is well known that legal origin of country is one of the key determinants of government quality (La Porta et al., 1999). If a proxy for legal origin is not included, TRANS correlates with the error term, resulting in estimation bias. Hence, CORRUPT, LEGAL_EN, and LEGAL_FR are incorporated as independent variables. With the aim of capturing these factors, I incorporated the following variables: PROTE (Protestant rate), CATHO (Catholic rate), LEGAL_EN (which is 1 if legal origin is French, otherwise 0), and LEGAL_FR (which is 1 if legal origin is French, otherwise 0). As nuclear energy plants increase, the likelihood of nuclear accidents also rises. The number of nuclear energy plants is included to control for this effect. Economic factors are captured by including population, GDP per capital, and government expenditure (% of GDP). These data were sourced from the Penn World Table (PWT 6.3) [8]. There appears to be a negative externality with regard to nuclear leakage caused by natural disaster. The possibility of suffering such an externality varies with regard to a nation's distance from Japan. Thus, the location of countries with regard to Japan influences changes in views about nuclear energy. Dummies for East Asian countries and European countries were incorporated into this model to capture such effects[9]. The experience of natural disasters is thought to be related to predictions regarding the outcome of natural disasters and, in turn,

[8] The data are available from the Center of International Comparisons at the University of Pennsylvania. http://pwt.econ.upenn.edu/ (accessed 28 March 2011).

[9] Considering the distance from Japan may be important because the spread of news regarding the disaster may take longer to reach more distant countries. However, it is difficult to measure distance because distance varies according to the location of the geographical point within a country from Japan. This is problematic especially when the land size is large. For instance, in the case of the United States, the distance between Los Angeles and Tokyo is different to the distance between New York and Tokyo. Therefore, instead of distance, regional dummies are incorporated even though these dummies do not accurately capture the distance.

influence views regarding nuclear power. To capture this effect, the total number of disasters that have occurred since 1970 are incorporated in the function.

It is likely that nuclear plants will exist in the countries where people favor nuclear energy. The OLS estimation results above possibly suffer from endogeneity bias because there may be a reverse causality between the dependent variable (DVIEW) and independent variable (NCLEAR). If people have a more positive view about nuclear energy, plans to build new nuclear plants are more likely to be supported. Consequently, the number of nuclear plants increases. Hence, NCLEAR can be considered as an endogenous variable. To control for this bias, instrumental variables were used to conduct the Limited Maximum Likelihood (LIML) Fuller version estimation. The building of nuclear energy plants requires sufficient land area. Furthermore, it is difficult to find the space to build plants in more densely populated countries. Therefore, population density and land area were used as instrumental variables in the LIML estimations. Staiger and Stock (1997) and Stock and Yogo (2005) show that the estimates are likely to be biased if the instruments in a regression are only weakly correlated with the suspected endogenous variables. The LIML Fuller version of the instrumental variable methods is robust with weak instruments. Furthermore, as the sample size in this paper is only 45, it can be considered a small sample. LIML estimates are robust with small samples, and so the risk of a significantly large bias is minor. Data were obtained from the World Development Indicators.[10]

4. Results

The estimation results for OLS are reported in Table 3. The results for the LIML estimation are exhibited in Table 4, while its first-stage results are in Table 5. In each table, the results using TRANS as a proxy for government transparency are shown in columns (1) and (4), whereas results using TRANS1 as proxies are in columns (2) and (5). In addition, results using TRANS2 as proxies

[10] The data are available from HP of World Bank http://databank.worldbank.org/ddp/home.do (accessed 28 March 2011).

are shown in columns (3) and (6). Results excluding individual level variables as independent variables are presented in columns (1)–(3), while those including individual level variables are reported in columns (4)–(6) in each table. Information regarding individual level variables could not be obtained for some observations; thus, the sample size was reduced from 27,423 in columns (1)–(3) to 24,677 in columns (4)–(6). The subjects within the groups correlated because they share the same condition, which is analogous to the time invariant fixed effects in the panel data regression model. In this paper, it is reasonable to assume that the observations may be spatially correlated within a country, as the preference of one respondent may well relate to the preference of another in the same country. Furthermore, the standard errors of the coefficients may be biased downward (Moulton 1990). To control for this bias, robust standard errors were calculated by clustering on the country; z-values were then obtained using cluster–robust standard errors.

First, I will discuss the results in Table 3. The results for TRANS, TRANS1, and TRANS2 yielded positive signs and were statistically significant in all estimations. The absolute values for TRANS are 0.03 and 0.04, indicating that a 1-point increase in the government transparency index increased DVIEW by 0.03 or 0.04 points. It is surprising to observe that transparency of government results in people having a positive view of nuclear energy, even directly after the Fukushima accident although its effect is considered small. It follows from this that the influence of government transparency does not change according to whether individual level variables are incorporated. Results for TRANS1 and TRANS2 are similar to those of TRANS, showing that the effect of government transparency is robust when alternative indices are used. I interpret the results as implying that citizens' views regarding nuclear energy were less likely to be influenced by the Fukushima accident with a more transparent government. Furthermore, the signs for the coefficients of VIEW(–1) are negative and statistically significant at the 1% level in all columns. The coefficient is –0.23 when individual level variables are excluded, and –0.24 when they are included. This indicates that the positive effect of VIEW(–1) is robust to alternative specifications. Most of the other control variables were not statistically significant and did not influence changes in views on nuclear energy.

Concerning individual level variables for the estimation in Table 3, the results are reported in Table A1 (see Appendix). Most of the variables are not statistically significant. In this study, I have chosen to focus on variables that did have a significant effect on the dependent variable. Table A1 shows that the coefficient of Full-time job dummy has the positive sign and is statistically significant when the reference group is retired people. This implies that the full-time workers are more inclined than retired people to have positive views on nuclear energy even after the Fukushima accident. The sign of the coefficient of Male dummy is positive and statistically significant at the 1% level in all columns, which means that males are more likely to be positive towards nuclear energy than females. It follows then that perceptions about risk differ between genders when a severe accident occurs. Thus, males are more likely to hold the same views even after a severe accident.

With regard to the LIML estimation results shown in Table 4, results for the control variables are not reported although they are included as independent variables. An over-identification test was used to test for exogeneity in the instrumental variables. Test statistics were not significant in columns (1)–(6) and, therefore, do not reject the null hypothesis that the instrumental variables are uncorrelated with the error term. This suggests that the instrumental variables are valid. Furthermore, an endogeneity test shows whether LIML is even necessary. Test statistics were not significant in columns (1)–(6) and do not reject the null hypothesis that NCLEAR is uncorrelated with the error term. Accordingly, the number of nuclear plants is not an endogenous independent variable when DVIEW is the dependent variable. This suggests that OLS is valid and so LIML is not necessary. However, to check the robustness of the OLS results, the LIML results are exhibited. In Table 5, the first-stage results show that the coefficients for Land area take the predicted positive sign only in column (1); however, none of the results are statistically significant. In contrast, the coefficients for Population density take the expected negative sign in all estimations and are statistically significant at the 1% level in all columns. The results for Population density as the instrumental variable are consistent with the prediction but Land area is not. In all columns in Table 4, TRANS, TRANS1, and TRANS2 yield a significant positive sign, which is similar to the results in Table 3. Furthermore, the signs for the coefficients of VIEW(–1) are negative and statistically significant in all columns, suggesting that controlling for endogeneity bias does not affect the results of VIEW(–1). I interpreted this result to suggest that citizens who favor nuclear energy were more likely to be affected by the Fukushima accident and have stronger negative views then before the accident. Hence, views regarding nuclear energy tend to converge. All in all, the results in Table 4 are very similar to those in Table 3. The estimation results are considered to be robust. These results strongly support Hypothesis.

The above evidence can be interpreted to indicate that citizens' views were not influenced by the Fukushima incident in countries with more transparent governments. Thus, it can be argued that government transparency played a critical role in the formation of views regarding nuclear energy before the Fukushima incident. This is so because information regarding nuclear energy after the Fukushima incident did not change their views, which is consistent with previous research on political persuasion (e.g., Zaller 1992; Prior 2006; Enikolopov et al., 2009).

5. Conclusions

The Fukushima incident renewed the debate regarding the issue of nuclear energy. The views of citizens regarding nuclear energy are thus believed to have been influenced by the Fukushima incident because some countries, in addition to Japan, changed their energy policies as a consequence of the Fukushima incident. Government policy is considered to reflect people's views and opinions, and as such it is worthwhile to investigate the reasons why views regarding nuclear energy changed worldwide after the Fukushima incident. This study used individual level data from 45 countries, with a sample size of 27,423 observations, to examine how government transparency influenced changes in views regarding nuclear energy before and after the 2011 Japanese disasters. It was observed that in the majority of countries studied in this paper that the rate of favoring nuclear energy declined after the disaster. However, empirical results have shown that people were less likely to be affected by news of the Fukushima accident when governments more frequently updated data released to the public. This result is in line with the belief-based model of persuasion (DellaVigna and Gentzkow 2010).

This finding clearly states that views regarding nuclear energy were less elastic to the news of the Fukushima incident in situations where people already held supportive views about nuclear energy as a result of information provided by their government before the incident. Thus, similar to belief-based models of persuasion (DellaVigna and Gentzkov, 2010), transparency of government enables people to have opinions on those matters that the government discloses sufficient information.

The importance of transparency, however, appears to depend on the condition of the "information market". The development and diffusion of cross-border media have created a competitive information market. Thus, people can obtain information about an incident even if a government attempts to conceal it (e.g., for the sake of nuclear energy industry). Consequently, people are less inclined to trust their government when the government does not disclose information. It follows then that the greater the level of government transparency, the greater the likelihood is that people will trust their government. In contrast, government transparency enables people to make optimal decisions because of an abundance of public information. That is, in the development process of cross-border media, the benefit from transparency increases for both citizens and governments. Such an inference has not been investigated in this paper. This remaining issue is to be addressed in future research.

References

Acemoglu, D, Simon J., Robinson, J. 2001. The colonial origins of comparative development: an empirical investigation', American Economic Review 91(5), 1369–1401.

Alt, J.E., Lassen, D.D. 2006. Fiscal transparency, political parties, and debt in OECD countries. European Economic Review 50, 1403-1439.

Arrunada, B. 2010. Protestants and Catholics: similar work ethic, different social ethic. Economic Journal 120, 890-918.

Becker, G., Murphy, K. 1993. A simple theory of advertising as a good or bad. Quarterly Journal of Economics 108, 942-964.

Besley, T., Burgess, R. 2002. The political economy of government responsiveness: theory and evidence from India. Quarterly Journal of Economics 117, 1415-1451.

Berger, E.M. (2010). The Chernobyl disaster, concern about the environment and life satisfaction. Kyklos 63, 1-8.

Bruns, C., Himmler, O. 2011. Newspaper circulation and local government efficiency. Scandinavian Journal of Economics 113(2), 470-492.

DellaVigna, S., Gentzkow, M. 2010. Persuasion: Empirical evidence. Annual Review of Economics, 2, 643-669.

Eisensee, T., Strömberg, D. 2007. News droughts, news floods, and U.S. disaster relief. Quarterly Journal of Economics 122(2), 693-728.

Enikolopov, R., Petrova, M., Zhuravskaya, E.V. 2009. Media and political persuasion: Evidence from Russia. CEPR Discussion papers 7257.

Escaleras, M.,Anbarci, N., Register,C. 2007. Public sector corruption and major earthquakes: A potentially deadly interaction. Public Choice 132(1), 209-230.

Gentzkow, M., Shapiro, J.M. 2004. Media, education and anti-americanism in the Muslim world. Journal of Economic Perspectives 18(3), 117-133.

Guiso, L., Sapienza, P., Zingales, L. 2003. People's opium? Religion and economic attitudes. Journal of Monetary Economics 50, 225-282.

Islam, R. 2006. Does more transparency go along with better governance? Economics and Politics 18, 121-167.

Kahn, M. 2005. The death toll from natural disasters: The role of income, geography and institutions. Review of Economics and Statistics 87(2), 271-284.

La Porta, R, Lopez de Silanes, F., Shleifer, A., Vishni, R. 1999. Quality of government. Journal of Law, Economics and Organization 15(1), 222–79.

MacCulloch, R., Pezzini, S. 2010. The roles of freedom, growth, and religion in the taste for revolution. Journal of Law and Economics 53, 329-358.

Moulton, B. R. 1990. An illustration of a pitfall in estimating the effects of aggregate variables on micro unit. Review of Economics and Statistics, 72(2), 334-38.

Prior, M. 2006. The incumbent in the living room: The rise of television and the incumbency advantage in U.S. house elections. Journal of Politics 68, 657-673.

Skidmore, M., Toya,H. 2002. Do natural disasters promote long-run growth? Economic Inquiry 40(4), 664-687.

Sobel, J. 2002. Can we trust social capital? Journal of Economic Literature 40(1), 139-154.

Staiger, D., Stock, J. 1997. Instrumental variables regression with weak instruments. Econometrica, 65, 557-586.

Stigler, G.J. 1961. The economics of information. Journal of Political Economy 69, 213-225.

Stigler, G.J., Becker, G. 1977. De gustibus non est dsuputandum. American Economic Review 67, 76-90.

Stock, J., Yogo, M. 2005. Testing for weak instruments in linear IV regression. in D. Andrews and J. Stock, eds., Identification and Inference for Econometric Models: Essays in Honor of Thomas Rothenberg, Cambridge: Cambridge University Press, 80-108.

Telser, L.G. 1964. Advertising and competition. Journal of Political Economy 72, 537-562.

Toya, H., Skidmore, M. 2007. Economic development and the impacts of natural disasters.

Economics Letters 94(1), 20-25.

WIN-Gallup International. 2011. Impact of Japan earthquake on views about nuclear energy: Findings from a Global Snap Poll in 47 countries by WIN-Gallup International.

Yamamura, E. 2010. Effects of interactions among social Capital, income and learning from experiences of natural disasters: A case study from Japan. Regional Studies 44(8), 1019-1032.

Yamamura, E. 2011. How does corruption influence perceptions of the risk of nuclear accidents?: cross-country analysis after the 2011 Fukushima disaster in Japan. MPRA Paper 31708, University Library of Munich, Germany.

Yamamura, E. 2012. Effect of free media on views regarding the safety of nuclear energy after the 2011 disasters in Japan: evidence using cross-country data. Kyklos 65(1), 132-141.

Zaller, J.R. 1992. The Nature and Origins of Mass Opinion. Cambridge University Press.

Table 1 Change in views regarding nuclear energy
(rate of favoring nuclear energy after a natural disaster) – (rate of favoring nuclear energy before a natural disaster)

Country	Difference (1)	Difference (sourced from the BBC) (2)
Austria	–4	
Azerbaijan	3	
Bangladesh	–13	
Belgium	–9	
Bosnia and Herzegovina	–3	
Brazil	–2	
Bulgaria	–6	
Cameroon	–4	
Canada	–8	
China	–13	
Colombia	–1	
Czech Republic	–2	
Egypt	–13	
Fiji	1	
Finland	–6	
France	–8	–10
Georgia	–9	
Germany	–8	–15
Greece	–2	
Hong Kong	–8	
Iceland	–6	
India	–9	–10
Iraq	–13	
Ireland	–4	
Italy	–4	
Japan	–23	–15
Kenya	–11	
South Korea	–1	
Latvia	–1	
Macedonia	–2	
Morocco	19	
Netherlands	–7	
Nigeria	–2	
Pakistan	–2	
Palestine	–9	
Poland	–6	

Romania	–10	
Russia	–11	–3
Saudi Arabia	–9	
Serbia	–4	
South Africa	4	
Spain	2	
Switzerland	–6	
Tunisia	–5	
Turkey	–4	
United States	–6	–1
Vietnam	–5	

Note: Serbia and Palestine are excluded in the regression estimation because independent variable data were not available.

Table 2 Definition of variables and their descriptive statistics

	Definition	Mean	Standard deviation
	Country level characteristics		
TRANS	Government transparency indicator: 1 (low)–6 (high)	5.1	1.0
TRANS1	TRANS + *foi 1*[(1)]: 1 (low)–7 (high)	5.7	1.4
TRANS2	TRANS + *foi 2*[(2)] 1 (low)–11 (high)	6.4	2.3
EXPE	Dummy for Russia and the United States; both experienced nuclear accidents (the Chernobyl and Three Mile Island accidents, respectively).	0.06	---
CORRUP	Corruption Perceptions Index (CPI) in 2009	4.85	2.30
PROTE	Protestant rate	0.13	0.22
CATHO	Catholic rate	0.26	0.34
LEGAL_EN	Takes 1 if legal origin is England, otherwise 0	0.26	---
LEGAL_FR	Takes 1 if legal origin is French, otherwise 0	0.31	---
NCLEAR	Number of nuclear power plants in operation	7.7	19.1
POP	Population (millions)	101.5	251.1
GDP	GDP per capita (million dollars)	1.9	1.4
GOVSIZ	Government expenditure regarding GDP	0.16	0.08
NDIS	Total number of natural disasters since 1970	96.5	139.9
EASIA	Dummies for East Asian countries (Japan, China, and Korea).	0.06	---
EUROP	Dummies for European countries.	0.46	---
	Individual level characteristics.		
VIEW(0)	Degree of respondent's favoring of nuclear energy after earthquake: 1 (strongly oppose)–4 (strongly favor)	2.56	1.06
VIEW(–1)	Degree of respondent's favoring of nuclear energy before earthquake: 1 (strongly oppose)–4 (strongly favor)	2.72	1.06
DVIEW	VIEW(0) – VIEW(–1)	–0.15	0.74

Age	Respondent’s age	41.5	15.7
Income 1 dummy	Low (Bottom quintile/20%): **Question: Compared with other families in your country, how would you describe your household income?**	0.20	---
Income 2 dummy	Medium low (Second quintile/20%): **Question: Compared with other families in your country, how would you describe your household income?**	0.22	---
Income 3 dummy	Medium (third quintile/20%) **Question: Compared with other families in your country, how would you describe your household income?**	0.22	---
Income 4 dummy	Medium high (fourth quintile/20%) **Question: Compared with other families in your country, how would you describe your household income?**	0.14	---
Income 5 dummy	High (top quintile/20%) **Question: Compared with other families in your country, how would you describe your household income?**	0.14	---
Education 1 dummy	Respondent’s education level is no education or only basic education	0.25	---
Education 2 dummy	Respondent’s education level is secondary school	0.43	---
Education 3 dummy	Respondent’s education level is a high level of education (e.g., university)	0.32	---
Retired dummy	Respondent is retired	0.15	---
Full-time job dummy	Respondent has a full-time job	0.54	---
Unemployed dummy	Respondent is unemployed	0.09	---
Student or housewife dummy	Respondent is a housewife or student	0.22	---
Female dummy	Respondent is male	0.49	---
Male dummy	Respondent is female	0.51	---
Rural resident dummy	Respondent resides in a rural area	0.28	---
Urban resident dummy	Respondent resides in an urban area	0.72	---

Note:
(1) *foi 1* is 1 if the Freedom of Information Act has been in existence, otherwise 0.
(2) *foi 2* is 1 if the Freedom of Information Act has been in existence for more than five years; however, if it is equal to 10 years or less the *foi 2* is 2, between 10 and 15 years it is 3, between 15 and 20 years it is 4, and over 20 years it is 5.

Source: VIEW(0), VIEW(–1), and DVIEW were obtained from WIN-Gallup International (2011). TRANS was sourced from Islam (2006) and NCLEAR from HP of European nuclear society (http://www.euronuclear.org/info/npp-ww.htm accessed on April 30, 2011). POP, GDP and GOVSIZ were obtained from Penn World Table 6.3.

(http://pwt.econ.upenn.edu/php_site/pwt_index.php. accessed at April 30, 2011). NDIS was obtained from the International Disaster Database (http://www.emdat.be. accessed on April 30, 2011). CORR was sourced from http://www.transparency.org/policy_research/surveys_indices/cpi (accessed on April 28, 2011). PROTE, CATHO, and LEGAL were sourced from La Porta et al. (1999), http://www.economics.harvard.edu/faculty/shleifer/dataset (accessed on April 30, 2011).

Table 3 OLS estimation
Dependent variable: DVIEW (the difference in views regarding nuclear energy)

	(1)	(2)	(3)	(4)	(5)	(6)
TRANS	0.03**			0.04**		
	(2.31)			(2.16)		
TRANS1		0.05***			0.04***	
		(3.55)			(3.18)	
TRANS2			0.02**			0.02**
			(2.47)			(2.42)
VIEW(–1)	–0.23***	–0.23***	–0.23***	–0.24***	–0.24***	–0.24***
	(–11.2)	(–11.4)	(–11.3)	(–11.1)	(–11.3)	(–11.2)
EXPE	–0.10	–0.12*	–0.08	–0.10	–0.12*	–0.09
	(–1.67)	(–1.93)	(–1.38)	(–1.64)	(–1.90)	(–1.45)
CORRUPT	–0.003	–0.001	–0.002	–0.004	–0.001	–0.0007
	(–0.18)	(–0.10)	(–0.12)	(–0.24)	(–0.08)	(–0.04)
PROTE	0.11	0.09	0.05	0.14	0.12	0.08
	(1.07)	(0.97)	(0.57)	(1.26)	(1.18)	(0.80)
CATHO	–0.07	–0.09	–0.09	–0.07	–0.08	–0.09
	(–0.97)	(–1.08)	(–1.05)	(–0.91)	(–1.03)	(–1.05)
LEGAL_EN	0.04	0.03	0.01	0.03	0.01	–0.005
	(0.71)	(0.49)	(0.20)	(0.50)	(0.28)	(–0.09)
LEGAL_FR	0.04	0.04	0.009	0.03	0.03	0.003
	(0.86)	(0.84)	(0.19)	(0.75)	(0.73)	(0.06)
NCLEAR	0.001	0.002	–0.003	0.001	0.0005	–0.0001
	(0.91)	(0.27)	(–0.32)	(1.00)	(0.44)	(–0.14)
Ln (POP)	0.02	0.02	0.03*	0.02	0.02*	0.03*
	(1.19)	(1.67)	(1.94)	(1.33)	(1.73)	(2.06)
GDP	$–0.04*10^4$	$–0.05*10^4$	$–0.04*10^4$	$–0.04*10^4$	$–0.05*10^4$	$–0.04*10^4$
	(–1.44)	(–1.64)	(–1.41)	(–1.37)	(–1.57)	(–1.41)
GOVSIZ	–0.12	–0.20	–0.22	–0.11	–0.19	–0.21
	(–0.48)	(–0.86)	(–0.91)	(–0.43)	(–0.82)	(–0.86)
EASIA	–0.06	–0.10	–0.08	–0.05	–0.09	–0.07
	(–0.65)	(–1.04)	(–0.93)	(–0.56)	(–0.91)	(–0.87)
EUROP	0.02	0.003	0.01	0.03	0.01	0.02
	(0.50)	(0.09)	(0.30)	(0.76)	(0.35)	(0.47)
NDIS	$–0.22*10^3$	$–0.17*10^3$	$–0.19*10^3$	$–0.24*10^3$	$–0.20*10^3$	$–0.23*10^3$
	(–1.18)	(–.95)	(–1.25)	(–1.29)	(–1.05)	(–1.38)
Constant	–1.10***	–1.16***	–1.09***	–1.16***	–1.21***	–1.15***
	(–5.17)	(–5.68)	(–5.18)	(-5.13)	(–5.46)	(–5.13)
Adjusted R^2	0.12	0.12	0.12	0.12	0.12	0.12
Individual characteristics.	No	No	No	Yes	Yes	Yes
Observations	27,423	27,423	27,423	24,677	24,677	24,677

Note: Values in parentheses are t-statistics calculated by robust standard errors obtained clustered at the country. *, ** and *** denote significance at the 10, 5 and 1% levels, respectively.

Table 4 LIML estimation
Dependent variable: DVIEW(the difference in views regarding nuclear energy)

	(1)	(2)	(3)	(4)	(5)	(6)
TRANS	0.04**			0.04**		
	(2.44)			(2.28)		
TRANS1		0.04***			0.04***	
		(3.64)			(3.19)	
TRANS2			0.02**			0.02**
			(2.33)			(1.99)
VIEW(–1)	–0.23***	–0.24***	–0.24***	–0.24***	–0.24***	–0.24***
	(–11.3)	(–11.5)	(–11.4)	(–10.7)	(–10.9)	(–10.9)
NCLEAR	0.0006	0.001	0.0002	–0.0004	0.0007	0.0005
	(0.36)	(0.60)	(0.14)	(–0.19)	(0.36)	(0.25)
Over-identification test	0.12 P-value = 0.72	0.06 P-value = 0.80	0.02 P-value = 0.88	0.15 P-value = 0.69	0.89 P-value = 0.34	1.26 P-value = 0.26
Endogeneity test	0.01 P-value = 0.89	0.10 P-value = 0.74	0.05 P-value = 0.81	0.54 P-value = 0.45	0.13 P-value = 0.71	0.02 P-value = 0.86
Individual characteristics.	No	No	No	Yes	Yes	Yes
Centered R^2	0.12	0.12	0.12	0.12	0.12	0.12
Observations	27,423	27,423	27,423	24,677	24,677	24,677

Note: Values in parentheses are z-statistics calculated by robust standard errors obtained clustered at the country. ** and *** denote significance at the 5 and 1% levels, respectively. Instrumental variables are population density and land area. All independent variables of the OLS estimation are included although the results are not reported.

Table 5 LIML estimation (First Stage)
Dependent variable: NCLEAR (Number of nuclear plants)

	(1)	(2)	(3)	(4)	(5)	(6)
Land area	$0.09*10^{-6}$	$–0.34*10^{-6}$	$–0.64*10^{-6}$	$–0.04*10^{-6}$	$–0.43*10^{-6}$	$–0.71*10^{-6}$
	(0.13)	(–0.47)	(–0.90)	(–0.06)	(–0.58)	(–0.96)
Population density	–5.66***	–6.25***	–5.73***	–6.38***	–6.90***	–6.27***
	(–2.85)	(–3.16)	(–3.35)	(–2.77)	(–3.08)	(–3.11)
F-test	F = 2.74 P-value = 0.00	F = 3.16 P-value = 0.00	F = 3.45 P-value = 0.00	F = 2.60 P-value = 0.02	F = 4.36 P-value = 0.00	F = 14.8 P-value = 0.00
F-test of excluded instruments	F = 5.20 P-value = 0.00	F = 6.24 P-value = 0.00	F = 5.80 P-value = 0.00	F = 4.53 P-value = 0.01	F = 5.32 P-value = 0.01	F = 4.83 P-value = 0.01
Individual characteristics.	No	No	No	Yes	Yes	Yes
Observations	27,423	27,423	27,423	24,677	24,677	24,677

Note: Values in parentheses are z-statistics calculated by robust standard errors obtained clustered at the country. *** denotes significance at the 1% level. Instrumental variables are population density and land area. All independent variables of the OLS estimation are included although the results are not reported.

Appendix

Table A1 (results of individual level variables from **Table 5**)
Dependent variable: NCLEAR (number of nuclear plants)

	(4) Table 3	(5) Table 3	(6) Table 3
Age	–0.0008	–0.0009*	–0.0009*
	(–1.60)	(–1.73)	(–1.69)
Income 1 dummy		<reference group>	
Income 2 dummy	–0.03*	–0.03*	–0.04*
	(–1.89)	(–1.83)	(–2.06)
Income 3 dummy	–0.04	–0.04	–0.05*
	(–1.58)	(–1.62)	(–1.88)
Income 4 dummy	–0.02	–0.02	–0.03
	(–0.94)	(–0.88)	(–1.16)
Income 5 dummy	–0.02	–0.01	–0.02
	(–0.80)	(–0.73)	(–1.19)
Education 1 dummy		<reference group>	
Education 2 dummy	–0.02	–0.02	–0.01
	(–1.23)	(–1.33)	(–1.05)
Education 3 dummy	–0.01	–0.01	–0.01
	(–0.76)	(–1.07)	(–1.00)
Retired dummy		<reference group>	
Full-time job dummy	0.05*	0.04*	0.05*
	(1.92)	(1.83)	(2.12)
Unemployed dummy	0.01	0.01	0.01
	(0.58)	(0.45)	(0.54)
Student or house wife dummy	0.03	0.03	0.03
	(1.02)	(1.02)	(1.14)
Female dummy		<reference group>	
Male dummy	0.07***	0.07***	0.07***
	(5.44)	(5.50)	(5.48)
Rural resident dummy		<reference group>	
Urban resident dummy	0.01	0.01	0.01
	(0.65)	(0.74)	(0.83)
Observations	24,677	24,677	24,677

Note: Values in parentheses are t-statistics calculated by robust standard errors obtained clustered at the country. * and *** denote significance at the 10 and 1% levels, respectively.