How does corruption influence perceptions of the risk of nuclear accidents?: cross-country analysis after the 2011 Fukushima disaster in Japan.

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Abstract. Japan's 2011 natural disasters were accompanied by a devastating nuclear disaster in Fukushima. This paper used cross-country data obtained immediately after the Japanese disaster to explore how, and the extent to which, corruption affects the perception of citizens regarding the risk of nuclear accidents. Endogeneity bias was controlled for using instrumental variables. The cross-country analysis showed that citizens in less corrupt countries tend to perceive there to be a lower possibility of nuclear accident.

Keywords: Natural disaster; Nuclear accident; Corruption; Japan
JEL classification: D73, D82, H12, Q54

1. Introduction

On March 11, 2011 one of the most devastating earthquakes in history hit Japan. The earthquake was accompanied by a tsunami arriving at the northeastern coast of Japan. Many precious lives, approximately 18,000, were lost because they were unable to escape the tsunami. Of those that did escape, hundreds of thousands lost their homes: "Estimates vary, but the World Bank and Japanese government say that there's somewhere between $122 billion and $235 billion worth of damage to clean up" (Hammer, 2011, 28). As a consequence of the 2011 natural disasters, the Fukushima Daiichi nuclear plants, facing the northeastern coast, were crippled, resulting in nuclear leakage. The nuclear leakage resulted in a mass evacuation of the areas surrounding the Fukushima Daiichi nuclear plants. Furthermore, the Japanese nuclear accidents have had a tremendous impact not only on the areas stricken by the natural disasters, but also areas some distance from the northeastern coastal area. Sufficient electricity could not to be supplied to Tokyo because of the nuclear accident. Once the demand for electricity outweighs its supply, power failures would occur over a large part of Tokyo. With the aim of avoiding such a situation, it was planned that in March 2011 that the electricity supply would be cut off in some areas in Tokyo. However, as a result of these cuts, economic activity slowed significantly, having a detrimental effect on the Japanese economy. The catastrophe that occurred in Japan was the result of not only a natural disaster but also a nuclear one. The nuclear disaster rating given for Japan's nuclear accident was level 7, a rating level that has only been used once before with the Chernobyl disaster. During the disaster process, the Japanese government was criticized because they did not provide accurate information regarding the situation at the nuclear plants. As a result, Japanese citizens now feel embarrassed and their levels of fear regarding the accident have increased. Furthermore, a number of foreign firms have relocated their offices from Japan to other Asian countries.

Catastrophes caused by natural and nuclear disasters can trigger controversy regarding nuclear policy, drawing greater attention to the issue and becoming a hot topic worldwide.[1] For example, Dempsey (2011) noted, "after the catastrophe in Japan, Mrs. Merkel reversed a pro-nuclear policy that she adopted just last year and temporary shut down seven of Germany's 17 nuclear plants." Despite the change in pro-nuclear policy, Merkel's conservative Christian Democrats suffered a major election defeat 2 weeks after the Japanese disaster. Furthermore, EU environment ministers gathered in Brussels and expressed support for a proposal from Austria to monitor the security of operating nuclear plants. The G8 Summit was held in France 2 months after the Japanese disaster, and Europe and Japan agreed to join forces in an effort to promote tighter international standards for nuclear safety. In contrast with Germany, France and the United States, however, have continued

[1] Kahn (2007) empirically examined the impact of disasters on risk regulation and provided evidence that liberal representatives were likely to increase the number of their votes in favor of risk regulation.

with their pro-nuclear energy policy. Such actions show the range in attitudes toward nuclear energy policy among G8 countries.

There are number of factors associated with the damage caused by natural disasters: economic condition (e.g., human capital), economic openness, size of government (Toya and Skidmore, 2007), and the media (Besley and Burgess, 2002; Eisensee and Strömberg, 2007). In addition, quality of governance is also thought to influence the level of damage caused by disasters. Governance, however, does not affect the likelihood that a natural disaster will occur. In contrast with natural disasters, technological disasters, such as a nuclear accident, are considered to be the result of human error. Thus, I would argue that the risk of nuclear disaster depends, in part, on the quality of governance. Hence, a citizen's perception regarding the risk of nuclear accidents appears to be associated with the quality of governance. With the exception of levels of natural resources, governance influences the view of citizens regarding nuclear energy, which is reflected in the nuclear policy of various countries.

It was not only the Japanese who were shocked by the 2011 disasters. Citizens worldwide were shaken by the devastation—especially those in countries with nuclear plants, with their thoughts turning to nuclear accidents in their own countries. The extent to which the Japanese disaster will influence the views of citizens regarding the possibility of nuclear accidents will be seen in their voting behavior, and, ultimately, in their nuclear policies. The classic work of Hinman et al. (1993) attempted to analyze the perception of risk regarding nuclear energy. Visucursi and Zeckhauser (2006) sought to ascertain the determinants of subjective disaster fatality risk. However, little is known about the effect that quality of governance may have on the subjective risk of nuclear plants. Recently, a number of works have found that unexpected disaster is associated with subjective well-being (e.g., Carroll et al., 2009; Luechinger and Saschkly, 2009). Since the occurrence of serious nuclear accidents such as Three Mile Island and Chernobyl, the security of nuclear energy has been brought to the public's attention worldwide. Berger (2010) has presented findings that Chernobyl's nuclear accident led citizens who lived far from Chernobyl to take an interest in that environmental issue immediately after the disaster. Almond et al. (2007) found that the accumulation of human capital in Sweden was affected by the Chernobyl nuclear accident, implying that the long-term effects of nuclear disaster crossed international boundaries. Thus, it is worth investigating the level of influence that the Fukushima accident has had on the perception of citizens who live far from the accident site. Of fundamental interest in this paper is how citizens around the world perceive Japan's disasters and how corruption influences the perception of those citizens. To this end, by using cross-country data collected after the Japan disaster, this paper examines how corruption in the public sector influences the view of citizens regarding the possibility of nuclear disaster. The key finding from this analysis was that public sectors with less corruption produce citizens who believe there to be a lower possibility of nuclear disaster.

The structure of this paper is as follows: section 2 proposes the hypothesis; data and method are explained in section 3; the estimation results are reported in section 4; and the final section presents the conclusion.

2. Hypothesis

Catastrophe is believed to increase through a combination of actions by nature and humans (Zeckhauser, 1996). Within a competitive market, competitive pressure will induce electricity companies to ensure the security of their nuclear plants. The current situation in Japan is that of a significantly contracted electricity market, with a large share of the market occupied by a few incumbent companies. Thus, electricity companies in Japan have sizable market power and obtain greater profits than in a competitive market.

Electricity companies are considered a special interest group and so use rent-seeking behavior to protect their vested interest. In response, corrupt government regulators have assisted the companies by erecting entry barriers for the purpose of providing monopoly profits for favored producers (Bliss and Di Tella, 1997). Public sector corruption enables favored industry companies to build plants that would otherwise fail government safety standards (Escaleras et al., 2007). The Tokyo Electric Power Co., which operates the Fukushima Daiichi nuclear plants, ignored warnings that the reactors were vulnerable. Government regulators in Japan have favored the Tokyo Electric Power Co., for example, "Just a month before a powerful earthquake and tsunami crippled the plant … government regulators provide a 10-year extension for the oldest of the six reactors at the power station despite warnings about its safety" (Tabuchi et al., 2011). The probability of a catastrophe had not been appropriately assessed and those values were not disseminated, which, in turn, resulted in poor outcomes (Zeckhauser, 1996). Thus, the catastrophe that struck the Fukushima nuclear plants may be the result of a conspiracy of nature and humans. If this holds true, the perceptions the risk of nuclear plants among citizens will be greater in public sectors with higher levels of corruption.

These considerations lead me to propose the following hypothesis:

Hypothesis: Corruption leads citizens to believe the possibility that a nuclear accident could occur.

3. Data and method

3.1. Data

Table 1 provides the definitions of the variables used in this paper and the results for the mean difference test between countries with and without nuclear plants. Table A1 in the appendix lists the countries used in this analysis. Approximately 2 weeks after Japan's 2011 natural disasters, a survey regarding nuclear energy was conducted by WIN-Gallup International (2011). Respondents in 39 countries were asked : "How high or low is your concern about the possibility of a nuclear incident in your country?" There were five response choices: "very high", "high", "medium", "low", and "very low". The response rates from each county are available from WIN-Gallup International (2011). Based on this survey, I calculated the rate of the respondents that believed there to be a high (or very high) possibility of a nuclear accident—dependent variable (PNACCI). The average PNACCI for countries with nuclear plants is 32.6%, whereas that for countries without nuclear plants is 49.4%. The difference is significant at the 1% level. This indicates that nuclear plants can be built because citizens believe that nuclear accidents are unlikely to occur.

The key independent variable in this analysis is a proxy for the degree of corruption. I used the Corruption Perceptions Index (CPI)[2] as the corruption proxy. The CPI scale has values from 0 (highly corrupted) to 10 (least corrupted). That is, the higher values on the CPI indicate less corruption. This index, which was launched in 1995, is published by Transparency International. The CPI has been widely used to measure cross-country corruption (for example, see Lambsdorff, 2006). The CPI is a composite index, drawing on 15 different polls and surveys from 9 independent institutions, conducted among business people and country analysts, and it includes residential surveys on both locals and expatriates. The CPI focuses on corruption in the public sector. The surveys used in compiling the CPI ask questions regarding the misuse of public power for private benefit, with a focus, for example, on bribe-taking by public officials in public procurement. The sources do not distinguish between administrative and political corruption. As presented in Table 1, the average CORR (degree of corruption) for countries with nuclear plants is 5.75 points, whereas that for countries without nuclear plants is 4.14. Furthermore, the CORR among them is significantly different at the 5% level. This implies that pro-nuclear energy policies tend to be supported in less corrupt countries.

The relationship between CORR and PNACCI (the perceived possibility of nuclear accident) is illustrated in Fig. 1(a). Canada, the Netherlands, Finland, and Iceland showed large CORR values of approximately 9 points and low PNACCI of approximately 15%. While CORR for Germany and Austria takes a similar value (8 points), PNACCI becomes higher (40% and 60% for Germany and Austria, respectively). This seems to be consistent with the political situation in these countries. That is, after Japan's disaster, the Green party won the election in Germany. Austria proposed that EU countries should monitor the security of operating nuclear plants. In contrast, Kenya, Nigeria, Morocco, Georgia, and China exhibit small CORR values of approximately 3 points and high PNACCI values of approximately 75%. On the whole, there is negative relationship between CORR and PNACCI. The corruption of the public sector is directly associated with the security of nuclear energy when a country possesses a nuclear plant. With regard to the sample limited to countries possessing nuclear plants, the relationship was demonstrated again; the negative relationship continued in Fig. 1(b). CORR for China, Brazil, India, and Romania was approximately 4 points. PNACCI for Brazil, India, and Romania was approximately 55%, while China's was 80%. This shows that PNACCI in China is remarkably higher than other countries with the same level of CORR. This result seems to reflect that fact that human rights are not well protected in China and, therefore,

[2] An important issue is how to define corruption. There are many definitions, and most share a common denominator that can be expressed as follows: "the abuse of public authority or position for private gains." The data are available at http://www.transparency.org/policy_research/surveys_indices/cpi (accessed February 2, 2011).

nuclear energy is not appropriately secured. Fig. 1(a) and (b) only illustrate the relationship between CORR and PNACCI and not the causality. Therefore, I will examine causality using regression estimation later in the paper.

To examine the hypotheses raised previously, the estimated function of regression takes the following form:

$$PNACCI_i = \alpha_0 + \alpha_1 NUCLE_i + \alpha_2 CORR_i + \alpha_3 NDIS_i + \alpha_4 Ln(GDP)_i + \alpha_5 ln(POP)_i + u_i,$$

where the dependent variable is prefecture $PNACCI_i$ in country i and α represents the regression parameters. u_i is the error term. NUCLE is number of existing nuclear plants.[3]

With regard to the hypothesis concerning the effect of corruption, I anticipate that α_2 will be negative. However, there seems to be a reverse causality that the perceived possibility of nuclear accidents has an influence on corruption in the public sector. This is because citizens who believe that nuclear accidents are likely to occur are inclined to have a great incentive to monitor the activities of the government and public sector. As a consequence, the results of OLS estimations are considered to suffer endogeneity bias. With regard to NUCLE, pro-nuclear policy is inclined to be supported and nuclear plants are likely to be built if citizens believe that nuclear accidents are unlikely to occur. I interpret this to be reverse causality, resulting in endogeneity bias. To control for the bias, I used instrumental variables to conduct GMM 2SLS (generalized method of moments two stage) estimations. With respect to endogeneity of NUCLE, the building of nuclear energy plants requires sufficient land area. It is difficult to find the space to build such plants in more densely populated countries. Hence, DENS (population density) and LAND (land area) are used as instrumental variables for the GMM 2SLS estimations. Table 1 shows that the average LAND of countries with nuclear plants is larger than that of countries without nuclear plants. Furthermore, LAND among the studied countries is significantly different at the 5% level. DENS and LAND variables were obtained from the World Development Indicators.[4] Existing literature provided evidence that legal origin and religion obviously influence the government performance (La Porta et al., 1999) and corruption (Treisman, 2000; Serra, 2006, Gokcekus, 2008; Pellegrini and Gerlagh, 2008). Escaleras et al. (2007) considered the total Protestant population rate and the legal origin dummy as exogenous variables, and used them as instrumental variables for corruption in the public sector to examine the effect of corruption on the level of damage from natural disasters.[5] In this paper, following Escaleras et al. (2007), variables capturing legal origin and religion can be

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[3] The data were collected from the homepage of the European Nuclear Society http://www.euronuclear.org/info/npp-ww.htm (accessed May 2, 2011).

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

[5] In addition to the Protestant rate of the total population and the legal origin dummy, Escaleras et al. (2007) used an index of democracy and the risk of political violence as instrumental variables. This paper, however, did not use these instrumental variables because the sample size decreases when these variables are used.

considered to be determinants of CORR and are therefore used to control for endogeneity in CORR. PROTE (Protestant rate), CATHO (Catholic rate), and LEGAL (which is 1 if legal origin is French, otherwise 0) are also used as instrumental variables. Data for PROTE, CATHO, and LEGAL were sourced from La Porta et al. (1999).

Following existing literature (e.g., Kahn 2005; Toya and Skidmore, 2007; Escaleras et al., 2007), with regard to control variables, the number of natural disasters since 1990 is included to capture the experience of natural disasters.[6] GDP (per capita GDP) and POP (population) are included to capture economic conditions.[7]

4. Results

Table 2 shows the results of the OLS estimation. The second stage results of the GMM 2SLS estimations are presented in Table 3(a). Tables 3(b) and (c) show the findings of the first stage of the GMM 2SLS estimations, showing the results for the determinants of NUCLE and CORR, respectively. In each table, results using a full sample are exhibited in columns (1) and (2), and the results for the sample of those countries possessing nuclear plants are shown in columns (3) and (4).

Table 2 shows that the sign for CORR is negative in all estimations, while being statistically significant in columns (1), (2), and (4). Column (3) is insignificant, in part, because a reduction in sample size appears to reduce statistical significance. Significant negative signs for NUCLE in all columns is interpreted as follows: the governments of countries possessing nuclear plants are considered to make a greater effort to ensure the safety of nuclear energy to lead their electorates to support pro-nuclear policy. However, there is the possibility of reversing the direction of causality when citizens consider nuclear energy as safety and therefore support pro-nuclear policy, resulting in the building of nuclear plants. As discussed later in the paper, the results of the GMM 2SLS estimation identify the effect of NUCLE on PNACCI. Coefficients of NDIS take positive signs and are statistically significant at the 1% level in all estimations. From the view of rational Bayesian learning, one would expect assessed risk to increase after experiencing a natural disaster. Thus, the experience of a natural disaster results in citizens perceiving a higher exogenous nature-related risk, thus, their perceived risk of nuclear accidents is higher.

Turning to the results in Table 3(a), we will check the validity of the GMM 2SLS estimations before discussing the results for each variable. The over-identification test provided a method of testing for exogeneity in instrumental variables. Test statistics were not significant in columns (1)–(4) and, therefore, do not reject the null hypothesis that the instrumental variables are uncorrelated with the error term. In addition, F-statistics show statistical significance in all estimations of Tables 3(b) and (c). This suggests that the estimation results of GMM 2SLS are valid in all estimations. NUCLE continues to produce significant negative signs in Table 3(a). Absolute

[6] NDIS was obtained from the International Disaster Database: http://www.emdat.be (accessed April 30, 2011).

[7] GDP and GOVSIZ come from Penn World Table 6.3. http://pwt.econ.upenn.edu/php_site/pwt_index.php (accessed April 30, 2011).

values for NUCLE are generally greater than 0.80. Compared with Table 2, NUCLE has greater absolute values. This suggests that countries possessing a greater number of nuclear plants appear to make an effort to decrease the possibility of nuclear accidents, and provide sufficient information regarding nuclear energy. As a consequence, its citizens perceive the possibility of a nuclear accident to be low. With regard to CORR, and in line with the results in Table 2, CORR yields negative signs and is statistically significant in columns (1)–(4). This implies that the negative effect of CORR on PNACCI is robust even after controlling for the endogeneity of NUCLE. Absolute values of CORR are 5.99 and 5.19 in columns (1) and (2), respectively, whereas they are 3.79 and 4.21 in columns (3) and (4), respectively. I interpret these results to suggest that a 1-point increase in CORR leads to an approximate 5% decrease in the perceived possibility of a nuclear accident for the full sample. Furthermore, a 1-point increase in CORR leads to an approximate 4% decrease in the perceived possibility of a nuclear accident for the sample limited to countries with nuclear plants. This implies that the influence of corruption decreases when the sample is limited to countries possessing nuclear plants. The combined results regarding CORR in Tables 2 and 3(a) support the hypothesis suggested earlier. The coefficient for NDIS takes the positive sign and is statistically significant at the 1% level in all estimations. The absolute values for NDIS range from 0.16 to 0.18, meaning that these values to not change when the sample is restricted to countries with nuclear plants. Concerning Ln(GDP) and Ln(POP), they do not become statistically significant in any columns. Hence, Ln(GDP) and Ln(POP) do not influence the perceived risk of nuclear accident.

With respect to the first stage results of GMM 2SLS, as is presented in Table 3(b), the coefficients for LAND take the positive sign in all estimation. In addition, LAND is statistically significant at the 5% level in columns (1) and (2), although it is not statistically significant in columns (3) and (4). The results for LAND support the assumption that sufficient land area is required to build nuclear plants. In Table 3(c), PROTE yields the positive sign and is statistically significant at the 1% level in columns (1)–(4), which is consistent with the evidence provided in existing literature (Treisman, 2000; Gokcekus, 2008; Pellegrini and Gerlagh, 2008).

5. Conclusion

Japan's 2011 natural disasters were accompanied by a devastating nuclear disaster, resulting in catastrophe. The G8 Summit was held in France 2 months after the Japanese disaster, with nuclear policy being a key issue. Thus, Japan's disaster had a tremendous impact on nuclear policy, not only in Japan but also worldwide. As suggested by Escaleras et al. (2007), corruption in the public sector may influence the level of damage caused by natural disasters because corruption can lead to reduced building safety, and, therefore, the reduced ability to withstand such disasters. Corruption is thought to affect not only the physical strength of buildings but also citizens' perceptions regarding the strength of buildings. If this is true, corruption can reduce a nuclear plant's resistance to natural disaster, such as earthquake and tsunami; thereby, influencing the perception of citizens regarding the risk of nuclear accidents. The primary contention in this paper is that public sector corruption can be expected to lead citizens to believe that nuclear accidents are likely to occur. This paper used cross-country data compiled immediately after the 2011 Japanese disasters to explore how, and the extent to which, corruption affects citizens' perceptions regarding the possibility of nuclear accidents. To control for endogeneity bias caused by corruption and existing nuclear plants, a GMM 2SLS model was used. From these estimations I found that citizens from less corrupt countries tend to believe that there is a lower possibility of nuclear accident.

Based on the results presented thus far in this paper, I propose that it is important that corruption in the public sector be reduced to ensure lower levels of perceived and objective risks regarding nuclear accidents. Transparency of government enables citizens to access accurate information, reducing information asymmetry between citizens and government. Thus, the cost of obtaining information decreases. As a result, government is expected to become less corrupt because politicians wish to increase their likelihood of re-election, and seek the support of the entire electorate rather than special interest groups. As asserted by Besley and Burgess, "Elections provided an incentive for politicians to perform which can be enhanced by development of the media. Through this mechanism we would expect responsiveness of the government to salient issues such as crisis management to be greater where the medial is more developed" (Besley and Burgess 2002, 1445). The role of the media is considered to have become more important in transmitting accurate information to ensure an effectively functioning democracy, especially when unexpected disasters occur. As was discussed and agreed at the 2011 G8 Summit, the risk of subsequent nuclear accidents is expected to be reduced. This result is, in part, thanks to a well-developed media network, consisting not only of newspaper, TV, and radio, but also the Internet.

The sample size of this paper is very small, reducing the accuracy of the estimations. Human capital and the development of the media are considered to be key factors that determine the perceived risk of nuclear plants. These variables, however, cannot be incorporated as independent variables because the sample size reduces when these variables are included in the function. Hence, it is necessary to use a larger sample for reporting results with greater accuracy. Furthermore, aggregated level cross-country data were used in this paper and, as such, individual characteristics such as sex, marital status, age, and income level cannot be controlled for. For a closer examination of the effect of corruption, individual-level data should be compiled and used. These issues need to be addressed in future studies.

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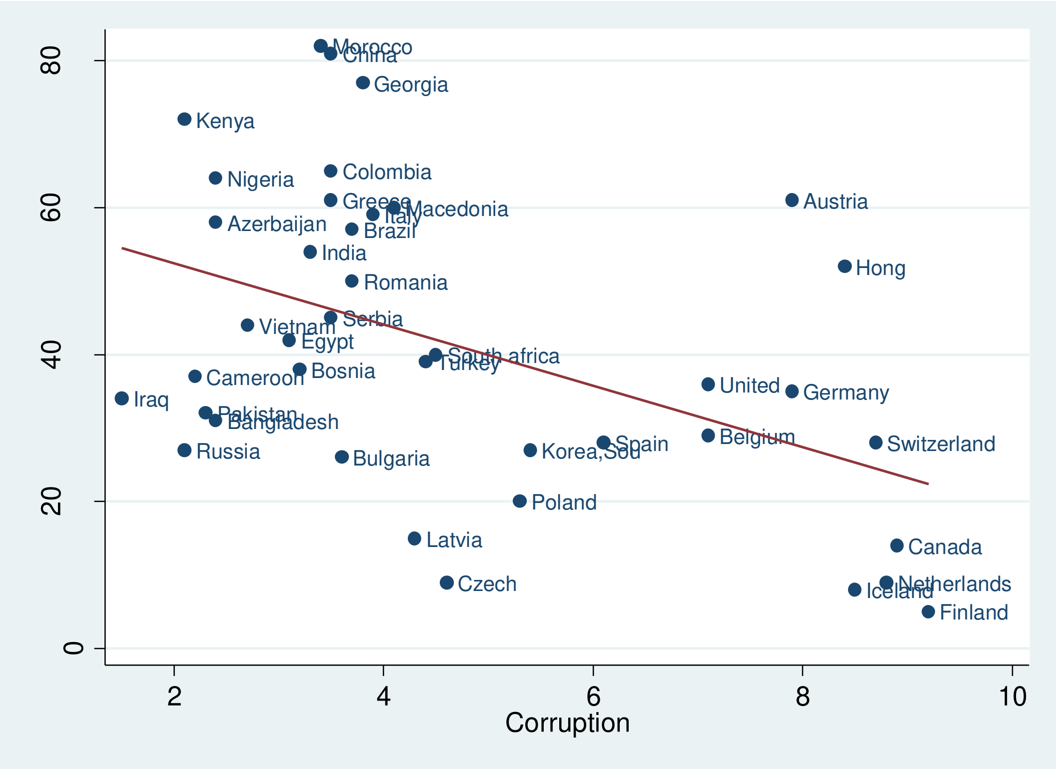

Fig. 1(a). Relationship between corruption and the perceived possibility of a nuclear accident

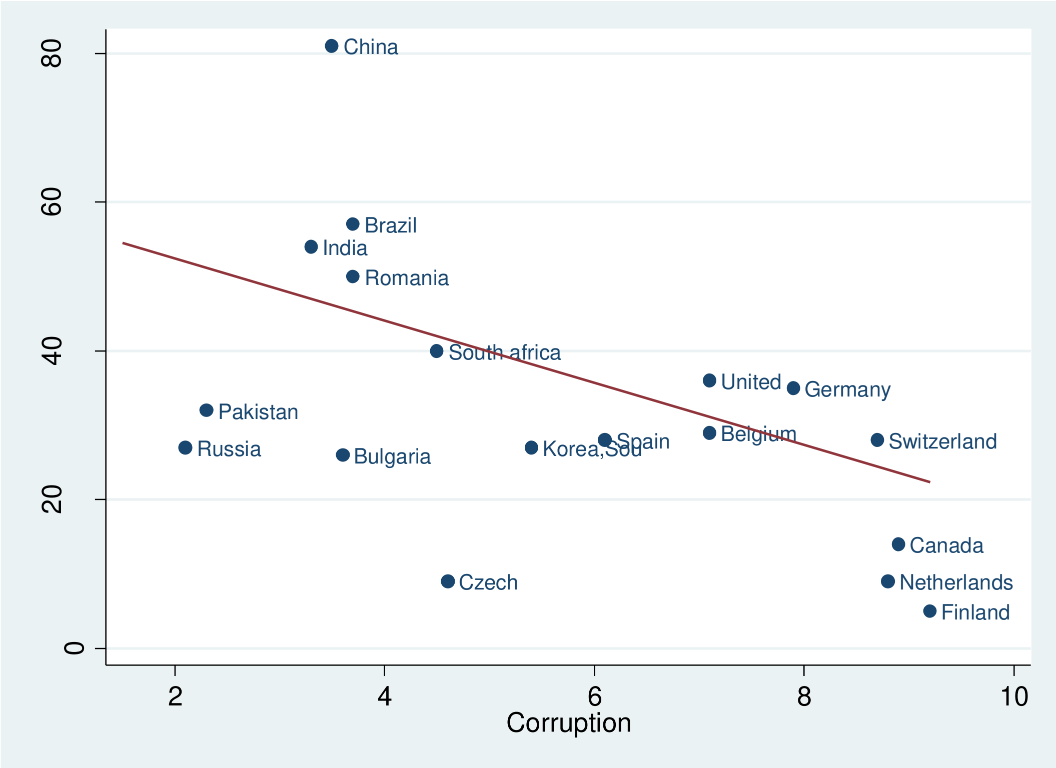

Fig. 1(b). Relationship between corruption and the perceived possibility of a nuclear accident (countries with nuclear plants)

Table 1. Variable definitions and mean difference tests

	Definition	With nuclear plants.	Without nuclear plants.	Absolute value of t-statistics
PNACCI	Rate of respondents think high (or very high) possibility of that nuclear accident (%)	32.6	49.4	2.73***
	Independent variables			
NUCLE	Number of nuclear plants existed in the country.	21.9	---	---
CORR	Corruption Perceptions Index (CPI) in 2009	5.75	4.14	2.47**
NDIS	Total number of natural disasters since 1990.	114	38	2.66**
GDP	GDP per capita. (Million dollars)	2.4	1.5	2.13**
POP	Population(million)	189.0	34.2	2.15*
	Instrumental variable			
DENS	Population density(/km^2)	17.3	38.1	0.70
LAND	Land area (thousand km^2)	3002.1	372.4	2.82***
PROTE	Protestant rate (%)	18.5	9.02	1.39
CATHO	Catholic rate (%)	28.9	24.7	0.41
LEGAL	It takes 1 if legal origin is French, otherwise 0.	---	---	---

Note: Values in parentheses are absolute t-statistics. *, **, and *** denote significance at the 10%, 5% and 1% levels, respectively. PNACCI was obtained from WIN-Gallup International (2011). CORR was sourced from http://www.transparency.org/policy_research/surveys_indices/cpi (accessed April 28, 2011). NUCLE was collected from HP of European Nuclear Society, http://www.euronuclear.org/info/npp-ww.htm (accessed May 2, 2011). GDP and GOVSIZ were sourced from the Penn World Table 6.3, http://pwt.econ.upenn.edu/php_site/pwt_index.php (accessed April 30, 2011). NDIS was obtained from the International Disaster Database http://www.emdat.be (accessed April 30, 2011). PROTE, CATHO, and LEGAL were sourced from La Porta et al. (1999), http://www.economics.harvard.edu/faculty/shleifer/dataset (accessed April 30, 2011). Countries where LEGAL takes 1 are exhibited in Table A1.

Table 2.

OLS estimations for dependent variable: PNACCI

	Full sample		With nuclear countries	
	(1)	(2)	(5)	(6)
NUCLE	-0.76***	-0.71***	-0.73***	-0.79***
	(-3.98)	(-3.89)	(-3.32)	(-4.18)
CORR	-4.05**	-3.87**	-4.28	-4.77*
	(-2.14)	(-2.14)	(-1.60)	(-1.99)
NDIS	0.16***	0.13***	0.16***	0.18***
	(3.73)	(4.33)	(4.16)	(8.44)
Ln(GDP)	4.23	4.44	13.0	13.5*
	(0.75)	(0.80)	(1.59)	(1.70)
Ln(POP)	-1.81		1.82	
	(-0.72)		(0.69)	
Constant	32.8	12.9	-97.4	-81.1
	(0.63)	(0.27)	(-1.44)	(-1.28)
Adjusted R^2	0.37	0.37	0.76	0.75
Observations	39	39	19	19

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

Table 3(a)

GMM2SLS estimations for dependent variable: PNACCI

			With nuclear countries	
	(1)	(2)	(3)	(4)
NUCLE	-0.88***	-0.89***	-0.82***	-0.78***
	(-3.18)	(-3.21)	(-2.97)	(-3.13)
CORR	-5.99**	-5.19**	-3.79*	-4.21**
	(-2.36)	(-2.47)	(-1.70)	(-2.20)
NDIS	0.18***	0.16***	0.17***	0.18***
	(3.62)	(3.72)	(3.99)	(5.63)
Ln(GDP)	8.88	8.42	12.9	12.4
	(1.43)	(1.40)	(1.55)	(1.59)
Ln(POP)	-2.05		1.80	
	(-0.90)		(0.89)	
Constant	0.75	-18.6	-97.5	-72.8
	(0.02)	(-0.38)	(-1.41)	(-1.12)
Over-identification	1.10	0.63	1.10	1.91
(Sargan) Test	P-value=0.77	P-value=0.88	P-value=0.57	P-value=0.59
Observations	39	39	19	19

Note: Values in parentheses are z-statistics calculated using robust standard errors. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Table 3(b)

Results of the first stage GMM 2SLS estimation for dependent variable: NUCLE.

			With nuclear countries	
	(1)	(2)	(3)	(4)
LAND	0.0001**	0.0001**	0.0001	0.0001
	(2.66)	(2.47)	(1.57)	(1.47)
DENS	-1.53	-1.69	9.62	7.82
	(-1.06)	(-1.17)	(0.74)	(0.63)
PROTE	0.09	0.10	-0.06	-0.03
	(1.29)	(1.47)	(-0.43)	(-0.24)
CATHO	-0.07	-0.08	-0.09	-0.12
	(-1.33)	(-1.60)	(-0.53)	(-0.75)
LEGAL	-0.96	-1.80	-6.35	-6.22
	(-0.27)	(-0.52)	(-0.53)	(-0.53)
NDIS	0.13***	0.11***	0.14***	0.12***
	(6.04)	(7.15)	(4.13)	(5.26)
Ln(GDP)	5.92**	6.88***	14.4**	15.8**
	(2.67)	(3.41)	(2.48)	(2.99)
Ln(POP)	-1.58		-2.21	
	(1.04)		(-0.69)	
Constant	-42.1	-65.5***	-116.1	-151.0***
	(-1.46)	(-3.65)	(-1.63)	(-3.11)
F-statistics	19.5	22.1	8.48	10.1
	P=0.00	P=0.00	P=0.00	P=0.00
Observations	39	39	19	19

Note: Values in parentheses are t-statistics calculated using robust standard errors. ** and *** denote significance at the 5% and 1% levels, respectively. Instrumental variables are land area and population density for 2009. These variables were obtained from the World Development Indicators 2010 (CD-Rom version).

Table 3(c)

Results of the first stage GMM 2SLS estimation for dependent variable: CORRU

			With nuclear countries	
	(1)	(2)	(3)	(4)
LAND	-0.007*10-2	-0.006*10-2	-0.006*10-2	-0.004*10-2
	(-1.41)	(-1.23)	(-0.96)	(-0.75)
DENS	0.37**	0.38**	1.41	1.59
	(2.36)	(2.47)	(1.35)	(1.57)
PROTE	0.04***	0.04***	0.04***	0.04***
	(5.36)	(5.30)	(3.79)	(3.76)
CATHO	0.01**	0.01**	0.01	0.02
	(2.16)	(2.43)	(1.23)	(1.52)
LEGAL	-0.44	-0.37	-0.53	-0.54
	(-1.16)	(-1.00)	(-0.54)	(-0.57)
NDIS	-0.0003	0.0009	-0.0008	0.0008
	(-0.15)	(0.56)	(-0.30)	(0.41)
Ln(GDP)	1.46***	1.38***	1.65***	1.51***
	(6.08)	(6.33)	(3.48)	(3.45)
Ln(POP)	0.14		0.22	
	(0.85)		(0.84)	
Constant	-11.3***	-9.27***	-14.3**	-10.9**
	(-3.62)	(-4.78)	(-2.48)	(-2.73)
F-statistics	25.8	28.8	14.2	16.6
	P=0.00	P=0.00	P=0.000	P=0.000
Observations	39	39	19	19

Note: Values in parentheses are t-statistics calculated using robust standard errors. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. Instrumental variables are land area and population density for 2009. These variables were obtained from World Development Indicators 2010 (CD-Rom version).

APPENDIX. Table A1. Lists of countries used in the analysis

With nuclear plants	Without nuclear plants
Belgium #	Austria
Brazil #	Azerbaijan
Bulgaria	Bangladesh
Canada	Bosnia and Herzegovina
China	Cameroon #
Czech Republic	Colombia #
Finland	Egypt #
Germany	Georgia
India	Greece #
Korea (South)	Hong Kong
Netherlands #	Iceland
Pakistan	Iraq #
Romania	Italy #
Russia	Kenya #
South Africa	Latvia
Spain #	Macedonia
Switzerland	Morocco #
United States	Nigeria
	Poland
	Turkey #
	Vietnam

Note: With the exception of the countries listed in Table A1, surveys were conducted for in a further eight countries. The question regarding the independent variable "possibility of nuclear accident" was not asked in these countries. Hence, these countries are not used in the analysis. # indicates the countries where LEGAL takes 1.