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Abstract

Previous research shows that decentralization plays a key role in the reduction of damage caused by natural disasters. The effect of decentralization will differ according a country's level of economic development. To investigate this matter further, this paper attempts to investigate how quality of institution influences the effectiveness of decentralization. This paper uses cross-country data from 1990 to 2000 to examine how decentralization, institution, and economic development influence the number of deaths caused by natural disasters. The major findings are that decentralization reduces deaths and its effect is strengthened in countries with lower level of public sector corruption and better functioning legal systems. Furthermore, the interaction between decentralization and high quality institutions has a greater contribution to the reduction of deaths in more developed countries. This implies that decentralization makes a greater contribution to mitigating damage in countries with higher quality institutions. However, when essential technology does not exist, decentralization and quality of institution play only a minor role in the mitigation of damage in the event of a natural disaster.

Keywords: Natural disaster, law and order, corruption, economic development.

JEL classification: D73; K10; O1; Q54

1. Introduction

Natural disasters have a considerable impact on economic conditions even in modern society. For instance, Haiti experienced an earthquake in 2010 resulting in tremendous physical damage and human losses. Further, the disaster rendered the society unstable and created conditions of anarchy. In this anarchic situation people have committed various crimes such as robbery and murder. On the other hand, a great earthquake hit Japan and together with the associated tsunami caused devastating damage to the coastal towns of northeastern Japan. However, after the disaster, people seemed to maintain order and cooperate. As a consequence of Haiti's earthquake, more than 200,000 people lost their lives (The United Nations 2010) while approximately 16,000 people died in Japan's earthquake and tsunami (National Police Agency of Japan 2012)[1]. The number of dead in Haiti's disaster is about 13 times larger than in Japan's. What caused so much difference in the death toll between the two disasters?

There are, of course, many differences between Haiti and Japan. It seems plausible that higher income countries can afford to provide disaster prevention measures and so reduce the damage. According to Penn World Table 7.0, prior to Haiti's and Japan's disasters, in 2009, GDP per capita in Japan was $31,957, which is about 22 times larger than that of Haiti ($1,444)[2]. The gap of per capita income between Haiti and Japan might be an indicator of the difference in death toll from the natural disasters. Disaster prevention measures are provided as a consequence of economic growth[3]. However, the association between GDP levels and the damage caused by natural disasters has been found to take an inverted U shape, rather than being monotonically negative (Kellenberg and Mobarak 2008)[4]. Income is an important factor in reducing damage, but has a very small effect when the scale of a disaster is small (Yamamura 2010)[5]. As argued by Albala-Bertrand (1993), the issue of disasters cannot be analyzed in isolation from the particular social and political setting where disasters

[1] National Police Agency of Japan (2012) is available at the web site (http://www.npa.go.jp/archive/keibi/biki/higaijokyo_e.pdf). Accessed May 5, 2012.
[2] PPP Converted GDP Per Capita at 2005 constant prices (Chain series). Data are available at Website of Penn World Table (http://pwt.econ.upenn.edu/php_site/pwt70/pwt70_form.php. Accessed May 6, 2012).
[3] Occurrence of natural disasters has an impact on economic growth (Strobl 2011 a, 2011b)
[4] Toya and Skidmore (2007) provided the following evidence regarding the numerous factors of natural disasters. First, the level of damage caused by natural disasters depends on the degree of economic development represented by GDP per capita, number of years at school, economic openness, and the comprehensiveness of a country's financial system.
[5] Income inequality increases the death rate in the event of natural disaster (Anbarci et al. 2005).

occur. Furthermore, in addition to economic conditions, previous research has found that institution plays a critical role in reducing the damage caused by natural disasters (Kahn 2005; Yamamura 2010) [6]. For example, Escaleras et al. (2007) found a relationship between countries with lower levels of corruption and less damage from natural disasters. According to the International Country Risk Guide (ICRG), there are indexes to measure institutional condition: degree of corruption and quality of legal system. In each index, a higher value implies better condition. In 2000's value, Japan's corruption score was 4.25 on the six-point scale, whereas Haiti's score was 1. What is more, Japan's legal quality score was 5 on the six-point scale, while Haiti's score was 1.5. These indicate that Japan's institution is better than Haiti's. Accordingly, the difference in number of deaths between Haiti and Japan may partly reflect difference in institutional quality between them. In this paper, I examine institutional factors and economic conditions in order to analyze the outcome of disaster. However, existing works have already shown that income level and institution play a critical role in reducing the damage caused by natural disasters (Kahn 2005; Toya and Skidmore 2007). Therefore this paper attempts to link these factors to political condition.

The occurrence of natural disasters is not systematically associated with the level of economic development (Kahn 2005). Governments are expected to prepare for natural disasters and to protect people should they happen. However, in order to deal with the problem of natural disasters, decision making should "be left to the people who are familiar with these circumstances, who know directly of the relevant changes and of the resources immediately needed to meet them" (Hayek, 1945, 524). This quotation indicates an argument that local government officials have greater knowledge and understanding of local demand than central government (Treisman 2002). An analysis of the outcome of Hurricane Katrina suggested that the centralized agency was not able to make the best use of dispersed information to coordinate the demand for available supplies (Sobel and Leeson 2006). Congruent with the assertion that we should solve the economic problems of society by some form of decentralization (Hayek, 1945), empirical evidence based on panel data suggests that decentralization plays a central role in mitigating the damage of natural disasters (Escaleras and Register 2010; Toya

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[6] The channels through which disasters influence economic conditions can be analyzed from a political economic point of view. The distortion of allocation through political economy channels is considered to indirectly influence the economic condition. In the case of the Federal Emergency Management Administration (FEMA) money flow, Garret and Sobel (2003) asserted that nearly half of all disaster relief is politically motivated rather than by need. Governmental failure increased the damage of Hurricane Katrina (Shughart II 2006). Interaction between the geographical features of New Orleans and the failure of the New Orleans levee system caused the catastrophe that followed Katrina (Congleton 2006).

and Skidmore, 2010)[7].

Fisman and Gatti (2002a) focused on an association between decentralization and corruption and found that decentralization is strongly associated with lower levels of corruption.[8] However, when there is extensive collusion between bureaucrats and local interest groups, it is possible for decentralization to have a detrimental influence on economic outcomes. Thus, decentralization is less likely to be effective if the public sector is corrupt. In other words, a less corrupt government possibly makes decentralization more effective. However, this inference is open to question and so should be empirically explored. Further, as suggested by Escaleras and Register (2010), decentralization has a different effect on developing and developed countries in terms of mitigating death rates in a natural disaster.[9] However, research in this field has yet to identify the underlying reason as to why levels of economic development appear to influence the effect of decentralization on deaths from natural disasters[10]. Accordingly, this paper considers the quality of institution and structure of government together, as opposed to independently, and focuses on the effect of the interaction among decentralization, institutional quality, and degree of economic development on natural disasters.

To this end, this paper uses cross-country data from 1990 to 2001 to examine the effect of interaction between decentralization and institution on deaths from natural disasters, and further investigates how the effect varies according to per capita GDP. Major findings of this paper are: (1) the levels of damage caused by natural disasters are lower in countries with a more decentralized government. (2) The effect of decentralization is greater in countries with less public sector corruption and better functioning legal systems. (3) The interaction between decentralization and institution makes a greater contribution to the reduction in deaths in countries with higher per capita income. The remainder of the paper is organized as follows: section 2 proposes the hypotheses to be tested; data and methods used are explained in section 3; section 4

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[7] The great Hanshin-Awaji earthquake hit Hyogo Prefecture in 1995. The governor of Hyogo Prefecture at this time asserted that "based on the experience of the disaster, decentralization is important to overcome the difficulty of disaster eventually" (Kaihara 2009, 6).

[8] Fisman and Gatti (2002b) found that the association between decentralization and corruption depends on the degree of devolution of revenue generation to local government.

[9] According to Escaleras and Register (2010), "…we do find fiscal decentralization to be associated with lower natural disaster death rates. Interestingly, however, there is some evidence that this relation is robust only developing countries.Since the existing data do not allow us to definitively explain this latter result, it would seem to be an interesting and potentially fruitful area for further study" (Escaleras and Register 2010, section 4).

[10] Toya and Skidmore (2007) provided the following evidence that the key determinants of damage are different between developing countries and OECD countries.

discusses the results of the estimations; and section 5 offers concluding observations.

2. Hypotheses

It is necessary to provide measures to protect people in the event of a natural disaster. For instance, disaster prevention technology is anticipated to reduce the detrimental impact of disaster on society. However, the cost of development of the technology is too high when the probability of natural disaster is low. Hence, sufficient disaster prevention technology cannot be supplied by the market and government is required to invest in the development of the prevention technology and provide it as public goods. The type of natural disasters that are expected to occur depends on geographical conditions such as topography, latitude and weather. In the Great-East Japan disaster in 2011, a large-scale earthquake hit Japan, but most of the damage was not caused by the earthquake but by the following tsunami and accidents at the Fukushima-Daiichi nuclear energy plant. Topographical features of the coastline increased the destructive power of the tsunami. Further, the nuclear energy plant is located on the coast, resulting in devastating accidents (The Japan Times, 2012)[11].

To prepare for disasters such as the Great-East Japan case, various factors should be considered. The existing knowledge about local conditions is important for providing the appropriate technology to prepare for a natural disaster. A central authority cannot make appropriate use of the local knowledge even if it has all that knowledge (Hayek, 1945). Hence, a single central authority finds it difficult to provide the technology that meets the local demands. That is, "we need decentralization because only thus can we ensure that the knowledge of the particular circumstances of time and place will be promptly used" (Hayek, 1945, 524). This view is consistent with the evidence that a decentralized local government is effective in protecting human life by preparing for unforeseen natural disaster and mitigating the associated damage (Escaleras and Register 2010; Toya and Skidmore 2010).

However, "the local representative bodies and their officers are almost certain to be of a much lower grade of intelligence and knowledge, than Parliament and the national executive" (Mill 1977, p. 422). In addition, local governments are apt to be susceptible to corruption, which lessens their ability to provide local public goods (Tanzi 1995). On the other hand, corruption is thought to motivate bureaucrats to direct public expenditure through channels that make it easier to collect bribes. Thus, the

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[11] The great Hanshin-Awaji earthquake hit western Japan in 1995, causing devastating damage to Kobe city, which is a port city. However, there was no damage caused by tsunami (Horwich, 2000; Kaihara, 2009).

productivity of the project is not considered in the selection of the investment project. This results in the distortion of resource allocation. Consequently, large-scale construction projects are more likely to be selected than maintenance expenditure. Accordingly, corruption reduces the public spending required to keep existing physical infrastructure well maintained and safe. A previous study (Tanzi and Davoodi 1997) showed that corruption is related to a lower percentage of well-maintained paved roads, and a higher percentage of electrical power system losses over total power output. From these results, the authors asserted that corruption reduces expenditure on maintenance and operations, resulting in low-quality infrastructure (e.g., Tanzi and Davoodi 1997; Tanzi 2002; Tanzi and Davoodi 2002). Therefore, the damage caused by natural disaster is thought to be magnified in more corrupt countries. In addition to the above reason, Escaleras et al. (2007) offered an example of public sector corruption where government inspectors allow contractors to ignore building codes. Furthermore, such contractors cannot be made to comply with building codes if they are operating within a poorly functioning legal system. As a result, buildings are seismically insensitive, which increases damage levels caused by a natural disaster.

Knowledge about local conditions possessed by local government is not used effectively for provision of disaster-prevention measures in corrupt government and in malfunctioning legal systems. To put it in another way, the effectiveness of decentralized local government is enhanced in less corrupt public sectors or when people are likely to obey the law. The following Hypothesis 1 is proposed.

Hypothesis 1: Decentralization is more strongly associated with lower levels of damage caused by natural disasters under better institutional conditions.

Even if the public sector is less corrupt and the legal system functions well, the importance of allocation of expenditure for disaster prevention appears to be lower in less-developed countries. Probability of deaths caused by malnutrition and endemic disease is far higher than that caused by natural disasters. Therefore, return on investment in measures for improvement of health is higher than that in measures for disaster prevention. Inevitably, basic needs for nutrition and prevention of endemic diseases are more important in these countries than disaster prevention. Hence, government expenditure for developing disaster prevention technology is thought to be smaller in less developed countries. What is more, assuming that there is a lack of appropriate construction engineering, seismically insensitive buildings can be constructed even when the public sector is not corrupt and a quality legal system is present. This implies that quality of institution is complementary to technology. Therefore, institution plays a greater role when more advanced technology exists. Advanced technology is less likely to exist in developing countries. Accordingly, the role of institutions in reducing the damage caused by disasters is considered to vary depending on the degree of a nation's economic development. I postulate Hypothesis 2 as follows:

Hypothesis 2: Interaction between decentralization and institution makes a greater contribution to the reduction of damage caused by natural disasters in more developed countries.

3. Data and Model

3.1. Data

The study period of this paper was determined because of the data limitations detailed below. Data regarding the death toll from natural disasters from 1900 to 2010 were available from EM-DAT (Emergency Events Database). In this paper, however, the data to be used for the proxy for public sector corruption and legal quality[12] were only available from 1984 to 2010 from the ICRG. Furthermore, the data for the proxy variable for decentralization of government covered the period 1972–2000, and was sourced from the IMF's Government Finance Statistics (GFS). To include these key variables in the estimations, I used data from 1990 to 2000 in this paper. Concerning the other control variables such as GDP (GDP per capita), population, fertility, land size, government size, and openness, these were collected from the World Bank (2011). Ethnic fractionalization was sourced from the home page (HP) of Marta Reynal-Querol, and political rights were obtained from Freedom House 1996. Data for GINI (income Gini coefficients) was gathered from the Standardized Income Distribution Database (SIDD) developed by Salvatore (2008).[13] Civil liberty and political liberty were collected from Freedom House 2001. Schooling years was obtained from Easterly and Levine (1997). As presented in Table A1 of the Appendix, the number of countries covered by the data ranges from 41 to 44. This number varies according to the specification of the estimations because the data regarding some independent variables could not be

[12] The measure for legal system quality is 'law and order' in the ICRG.
[13] The paper used SIDD-3, which is an interpolated and extrapolated version of SIDD-2 incorporating in-sample and out-of-sample estimates for 1955–2005.

collected for certain countries in certain years. Definitions and the basic statistics for the variables used in this paper are presented in Table 1. Further, the sources of all the data is summarized in Table A2, in the Appendix.

I now turn to the measures of public sector corruption and the state of legal systems. ‘Public sector corruption’ indicates the likelihood of senior government officials demanding special payments in the form of bribes. Thus, the ICRG corruption index captures financial corruption. ‘Public sector corruption’ values range from 0 (corrupt) to 6 (less corrupt) with larger values indicating less corruption. This measure can be interpreted as incorruption rather than corruption and so is denoted as *Incorruption*. ‘Quality of legal system’ reflects the results of assessments regarding (1) the strength and impartiality of the legal system and (2) observation of the law by the people. ‘Quality of legal system’ values range from 0 (poor) to 6 (good) with larger values indicating better legal systems. This variable is called *Law and order*. As exhibited in Table 1, the mean value and the standard deviation for the ICRG corruption (legal quality) index are 4.56 and 1.31 (4.80 and 1.44), respectively.

With regard to decentralization, I used the ratio of total sub-national government expenditure to total government expenditures, which has been commonly used in previous research (e.g., Panizzi 1999; Fisman and Gatti, 2002a; Escaleras and Register 2010; Toya and Skidmore 2010). As presented in Table 1, the minimum value of the dependent variable, *Deaths*, is 0. Hence, a Tobit model is used in this paper in preference to a simple OLS model.

Table 1 shows that the mean value of the number of deaths from disasters is 205 and its standard deviation is 1,343, which is nearly 7 times larger than the mean value. The maximum and minimum values of the number of technological disasters are 21800 and 0, respectively, indicating a large gap. In addition, Table 2 shows more detailed statistics regarding the distribution of number of deaths caused by natural disasters. The sample shows that there were no deaths in 58.7% of the observations. The number of fatalities within the ranges of 1–99 and 100–999 deaths was 26.1% and 10.6%, respectively. In contrast, the number of deaths over 10,000 was only 0.56%. Considering these results jointly suggests that the number of deaths are over-dispersed. The number of deaths from disasters is count data and does not take a negative value. Compared with OLS or a Tobit model, the Poisson model is more appropriate for the estimation in this situation because the estimation results for count data will suffer bias in OLS where dependent values are allowed to take both negative and positive values. Furthermore, the dependent variable must take 0 or 1 in a Probit model. A Probit model is more suitable to analyze qualitative data than count data. However, in the Poisson model, it is assumed that the mean of a dependent variable is equal to its variance. As discussed above, the number of deaths from disasters is over-dispersed and its variance is large. The use of the Poisson model here causes a downward bias and inflates z-statistics, and as such, the negative binominal model is preferred (Wooldridge 2002, Ch. 19). The negative binominal model is applied for empirical analysis to examine the effect of natural disasters in previous research (e.g., Anbarci et al. 2006; Escaleras et al. 2007; Kellenberg and Mobarak 2008) because the damage caused by natural disasters is characterized by over-dispersion. In line with previous literature, in addition to a Tobit model, the negative binominal model is also used in this paper. In the Tobit model, ln (1+deaths) was used as a dependent variable as in previous research (Kahn 2005; Escaleras and Register 2010; Toya and Skidmore 2010). This can attenuate the over-dispersion of the number of deaths[14]. Cursory examination of Figure 1 reveals that ln (1+deaths) is negatively associated with *Incorruption*. In addition, looking at Figure 2 shows that ln (1+deaths) is negatively associated with *Law and order*. It follows from these figures that the better the institutional quality, the smaller the number of deaths in the natural disaster. This is in line with the inference presented in the previous section.

The estimated function takes the following form:

$$\begin{aligned} Deaths_{it} = {} & \alpha_0 + \alpha_1 Incorruption_{it} + \alpha_2 Legal_{it} + \alpha_3 Decentralization_{it} + \alpha_4 Ln(\text{GDP})_{it} + \\ & \alpha_5 Land_{it} + \alpha_6 Population_{it} + \alpha_7 Openness_{it} + \alpha_8 Ln(Size\ of\ government)_{it} + \alpha_9 Gini_{it} \\ & + \alpha_{10} Ethnic\ fractionalization_i + \alpha_{11} Political\ right_i + \alpha_{12} Liberty_i + \\ & \alpha_{13} Ln(Scholing)_i + \alpha_{14} Time\ trend_t + e_{it}, \end{aligned}$$

where the dependent variable is the number of deaths caused by natural disasters in country *i* and in year *t*. The error term is denoted by *e* and α represents the regression parameters. Unobserved time-invariant features of a country are not controlled, although the structure of data used in this paper is panel data. Indexes for institutional quality such as degree of corruption and legal system are deep-seated and slow-moving parameters. Hence, for estimations, between country variations make more sense than within country variations. The fixed effects estimations report within country variation effects and so are not helpful in this paper. Hence, I pooled the data and then applied the Tobit model and the negative binominal model for estimations.

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[14] However, when *y* is a dependent variable, "for strictly positive variables, we often use the natural log transformation, log(*y*), and use a linear model. This approach is not possible in interesting count data applications, where *y* takes on the value zero for nontrivial fraction of the population" (Wooldridge 2002, p. 645). Therefore, careful attention is required when interpreting the results of the Tobit model.

The higher the quality of institution, the lower the level of damage from natural disasters. Therefore, I predict the coefficients for *Incorruption* and *Legal* to have a negative sign. If decentralization reduces the number of deaths from natural disasters, the coefficient of *Decentralization* will have a negative sign. Toya and Skidmore (2007) produced evidence that the determinants of damage resulting from natural disasters will differ depending on a nation's degree of economic development. Hence, a logarithm of GDP per capita represented as *Ln(GDP)* is incorporated. In addition to the primary model above, for the purpose of examining *Hypothesis 1,* the interaction terms of *Incorruption* and *Decentralization* (and *Legal* and *Decentralization*) were included as independent variables. If *Hypothesis 1* is supported, their coefficients have a negative sign. In addition, with the aim of examining *Hypothesis 2,* these interaction terms were further interacted with *Ln*(GDP). That is, *Incorruption** *Decentralization** *Ln(GDP)* and *Legal** *Decentralization** *Ln(GDP)* were incorporated. If *Hypothesis 2* is supported, their coefficients have a negative sign.

In addition to *Incorruption*, *Legal* and *Decentralization*, following Toya and Skidmore (2010), further aspects of a country's political condition were captured by *Political right* and *Liberty.* To capture socio-economic heterogeneity, *Gini* was included, which was also used in Kahn (2005) and Toya and Skidmore (2010). Furthermore, I included *Ethnic fractionalization*, which was also used in the estimation of Escaleras and Register (2010). To control for size of country, *Land* and *Population* are included. *Trend* was included to capture the unobserved time trends during the study period. Other control variables, as used by Toya and Skidmore (2007, 2010), *Fertility*, *Size of government, Schooling* and *Openness* are also incorporated.[15] *Ethnic fractionalization, Political right, Liberty, Schooling* are the value in a certain year because these variables could not be obtained for every year. That is, they are time invariant variables.

4. Results

The estimation results of the negative binominal model are exhibited in Tables 3 and 5(a) and (b). Further, the results of the Tobit model are exhibited in Tables 4 and 6(a) and (b). Tables 5(a) and (b), and 6(a) and (b) present the estimation results of key interaction terms such as *Incorruption*Decentralization* and *Legal*Decentralization*. In each table, the results of the estimation including all control variables are shown in columns (1)–(3), and those where some variables were omitted to increase observations

[15] Number of years at school and M3/GDP were incorporated as independent variables by Toya and Skidmore (2007). There is no panel data for number of years at school and it is captured by country dummies. The sample size is drastically reduced if M3/GDP is included. Hence, these variables are not included.

are shown in columns (4)–(6).

I begin by interpreting the results of Table 3. As expected, *Incorruption* yields the negative sign and is statistically significant in all columns, which is consistent with the previous research of Escaleras et al. (2007). Further, *Legal* produces similar results; it yields the negative sign and is statistically significant at the 1% level in all columns. The coefficient of *Decentralization* takes the negative sign in all estimations and it is statistically significant with the exception of column (5). This is in line with previous research (Escaleras and Register 2010; Toya and Skidmore 2010). Thus, quality of institution and decentralization are associated with lower numbers of deaths from natural disasters. As for economic significance, absolute values of the coefficient of *Incorruption* range between 0.41 and 0.65. This can be interpreted as implying that a one-point increase of *Incorruption* on the six-point scale reduced the death toll annually by 0.41–0.61%. Absolute values of the coefficient of *Legal* range between 0.50 and 0.91. This implies that a one-point increase of *Legal* on the six-point scale reduced the death toll annually by 0.50–0.91%. In addition, absolute values of the coefficient of *Decentralization* range between 0.03 and 0.04. This suggests that 1% increase in share of sub-national expenditures reduced the death toll annually by 0.03–0.04%. Concerning the other control variables, I intend to focus on the statistically significant results. The significant negative sign of *Openness* in columns (1) and (3) is in line with Toya and Skidmore (2007; 2010). This, to a certain degree, implies that the import of advanced disaster preventive technology reduces the damage caused by natural disasters. The significant positive sign of *Land* suggests that natural disasters more frequently occur when the land size is larger. This reflects the higher probability that natural disasters will occur in larger countries, when all other things are considered equal. The significant positive sign of *Population* shows that larger populations are more likely to be exposed to the shock of natural disasters. *Ethnic fractionalization* produces the positive sign and is statistically significant in all columns. This is contrary to the results of Escaleras and Register (2010), but consistent with their expectation. This result can be interpreted as suggesting that *Ethnic fractionalization* heightens ethnic tensions, which makes it more difficult for a country to agree on and develop public services such as disaster mitigation. The significant positive signs of *Liberty* in columns (1)–(3) reflects that civil and political liberty enables people to prepare more appropriately for the occurrence of unforeseen events such as natural disasters.

Table 4 shows that the coefficients of *Incorruption*, *Legal and Decentralization* have the predicted negative sign in all estimations. The coefficient of *Decentralization* is statistically significant at the 1% level in all columns. However, as shown in columns (1) and (4), *Legal* is not statistically significant when both *Incorruption* and *Legal* are included. In column (1), *Incorruption* is also not statistically significant. The correlation coefficient between *Incorruption* and *Legal* is 0.71 at the 1% level. Hence, there is the possibility that collinearity between them has caused the insignificant result. However, in columns (2), (3), (5) and (6), *Incorruption* and *Legal* are statistically significant. Overall, the estimation results of Table 4 are almost the same as those of Table 3, indicating that the results of Table 4 are robust to alternative specification. However, the values of the coefficient can be interpreted differently from those of Table 3 because the dependent variable takes a log-form. Turning to economic significance, absolute values of the coefficient of *Incorruption* are 0.43, 0.39 and 0.68 in columns (2), (4) and (5), respectively. This can be interpreted as suggesting that a one-point increase of *Incorruption* on the six-point scale reduced the death toll annually by 0.43–0.68%. Absolute values of the coefficient of *Legal* are 0.58 and 0.38 in columns (3) and (6), respectively. This implies that a one-point increase of *Legal* on the six-point scale reduced the death toll annually by 0.38–0.58%. In addition, absolute values of the coefficient of *Decentralization* range between 0.06 and 0.08. This implies that a 1% increase in share of sub-national expenditures reduced the death toll annually by 0.06–0.08%.

I now turn to the key interaction terms presented in Table 5(a). In Column (1) the *Incorruption*Decentralization* hasa negative sign and is statistically significant at the 1% level, whereas *Legal*Decentralization* produces the negative sign but is not statistically significant. As explained previously, there seems to be collinearity between *Incorruption* and *Legal,* which caused the insignificant result of *Legal*Decentralization*. The results in columns (3) and (5) are less likely to suffer from the problem of collinearity because *Incorruption* and *Legal* are included separately. In column (3), the coefficient of *Incorruption*Decentralization* continues to take the significant negative sign. In contrast, in column (5), the coefficient of *Legal*Decentralization* takes a significant sign while z-statistics is –2.00, which are statistically significant at the 5% level. These results are consistent with *Hypothesis 1.* As for *Incorruption*Decentralization*Ln(GDP)*, in columns (2) and (4), its coefficient took the negative sign and was statistically significant at the 1% level. With respect to *Legal*Decentralization*Ln(GDP)*, in column (2), its sign was positive despite being statistically significant. However, after controlling for collinearity in column (6), its sign became the predicted negative and was statistically significant. These results are congruent to *Hypothesis 2.* In addition to statistical significance, economic significance of these interaction terms is interpreted as follows: absolute values of the coefficient of

*Incorruption*Decentralization* is 0.05. This can be interpreted as suggesting that a one-point increase of *Incorruption* on the six-point scale increases the marginal effect of *Decentralization* on number of deaths by 0.05. Furthermore, the absolute value of *Incorruption*Decentralization*Ln(GDP)* is about 0.005 or 0.006. Hence, a 1% increase of GDP per capita raises the interaction effect of *Incorruption* and *Decentralization* by 0.005 or 0.006. Absolute value of the coefficient of *Legal*Decentralization* is 0.02. It can be interpreted as suggesting that a 1% increase of *Legal* on the six-point scale increases the marginal effect of *Decentralization* on number of deaths by 0.02. Furthermore, absolute value of *Legal*Decentralization*Ln(GDP)* is about 0.002 in column (6). Hence, a 1% increase of GDP per capita raises the interaction effect of *Legal* and *Decentralization* by 0.002.

The results exhibited in Table 5(b), use the same sample as in column (4) Table 3. Column (1) in Table 5(b) shows the predicted negative signs although the coefficient of *Incorruption*Decentralization* is not statistically significant. Column (2) in Table 5(b) shows the predicted negative signs although the coefficient of *Legal*Decentralization* LN(GDP)* is not statistically significant. However, I see from columns (3)–(6) that all coefficients continue to have negative signs and become statistically significant at the 1% level. In terms of economic significance, the absolute value of *Incorruption*Decentralization* is 0.03 in column (3) is smaller than that in Table 5(a). The absolute value of *Incorruption*Decentralization*Ln(GDP)* is 0.002, which is also smaller than that in Table 5(a). On the other hand, absolute values of *Incorruption*Decentralization* and *Incorruption*Decentralization*Ln(GDP)* are the same as those in Table 5(a). That is, in Table 5(b), the economic significance of the interaction effect of *Incorruption* is almost the same as that of *Legal.*

With respect to statistical significance, results of Tables 6(a) and (b) using a Tobit model are similar to those of Table 5(a) and (b). The joint consideration of Tables 3, 4, 5(a) and (b), and 6(a) and (b) reveals that *Hypotheses 1* and *2* are strongly supported. Furthermore, as shown in Table 6(b), the absolute value of *Incorruption*Decentralization* is 0.03, while that of *Legal*Decentralization* is 0.02. The absolute value of *Incorruption*Decentralization*Ln(GDP)* is 0.002, and the absolute value of *Legal*Decentralization*Ln(GDP)* is 0.001. In short, economic significance of the interaction effect of *Incorruption* is larger than that of *Legal.* Combined results of Tables 5(a) and (b), and 6(a) and (b) indicate that the interaction effect of *Incorruption*Decentralization* (or *Incorruption*Decentralization*Ln(GDP)*) is similar or larger than that of *Legal*Decentralization* (or *Legal*Decentralization*Ln(GDP)*).

5. Conclusions

Even in modern society, humans cannot control the occurrence of natural disasters. The ability to cope with natural disaster is a central policy issue around the world. For instance, decentralized local government enables the local information to be more useful than it is for centralized government (Hayek, 1945). Therefore, decentralization is expected to reduce damage by natural disasters. Existing works support this inference (Escaleras and Register 2010; Toya and Skidmore, 2010). Effectiveness of decentralization seems to be affected by institutional and economic conditions. I attempted to explore the conditions under which decentralization makes a greater contribution to reducing the damage from disasters. To this end, this paper used cross-country data to examine the effect of interactions between decentralization, institution, and per capita GDP on the number of deaths from natural disasters. It was found that decentralization reduces the number of deaths and its effect was greater in countries with less public sector corruption and better functioning legal systems. Furthermore, the interaction between decentralization and institution had a more significant effect on the reduction of deaths in more developed countries. This is contrary to previous research suggesting that decentralization is not important in reducing the number of deaths from disasters in developed countries (Escaleras and Register 2010).

The causality between economic development and institutional change is ambiguous. That is, institutional change can be considered as a consequence of economic development and economic development can be enhanced by institutional change. Therefore, developing countries with high-quality institution require greater support because the assistance will be more effective. From the evidence presented in this paper, I determine the policy implication that the transfer of disaster prevention technology should be extended to countries with higher levels of decentralization, less corrupt public sectors, and well-established legal systems. Such a policy is expected to enhance decentralization. Further the policy is expected to give the public sector the incentive to be less corrupt, and to make the legal system function well. Eventually, the policy of transfer of disaster prevention technology encourages improvements in institutional condition in tandem with decentralization. Disaster prevention technology is more useful and required in countries prone to suffer from disasters. The effect of the policy to transfer the disaster prevention technology on institution and structure of government is thought to be larger in countries where natural disasters occur more frequently. The exogenous shock, such as a natural disaster, is possibly a catalyst to improve institutional effects and enhance decentralization.

As stressed in previous research (Kahn 2005, Escaleras et al., 2007; Escaleras and Register 2010), proxies of institution are regarded as endogenous variables, leading to endogeneity bias. In this paper, the bias was not controlled for. Hence, the estimation results possibly suffer from endogeneity biases stemming from proxy variables for institution such as decentralization, corruption, and law and order. It is thus necessary to control for such bias. This is a remaining issue to be addressed in future research.

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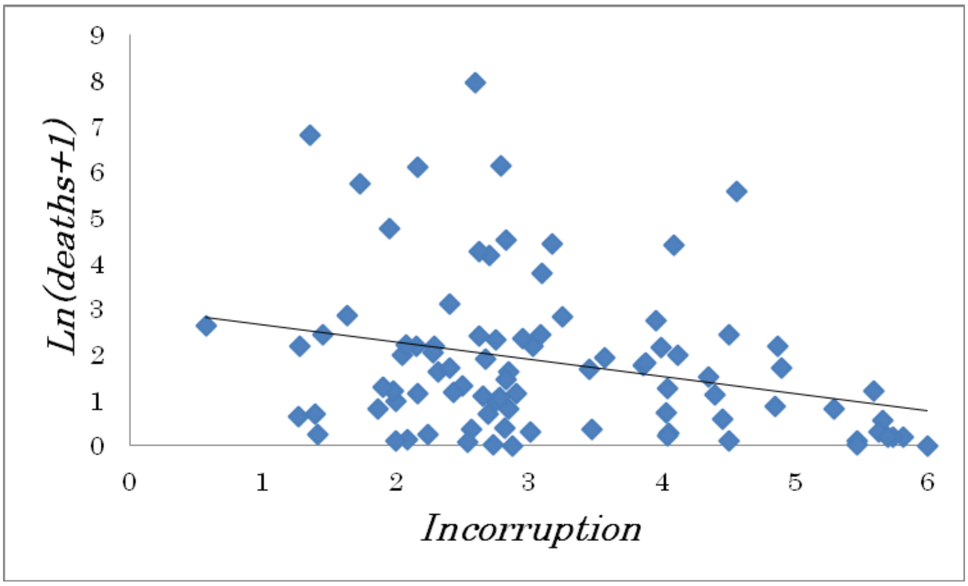

Figure 1. Association between *incorruption* and number of deaths.

Note: Values are average of *ln(deaths)* and that of *Incorruption* during 1990-2000 in each country.

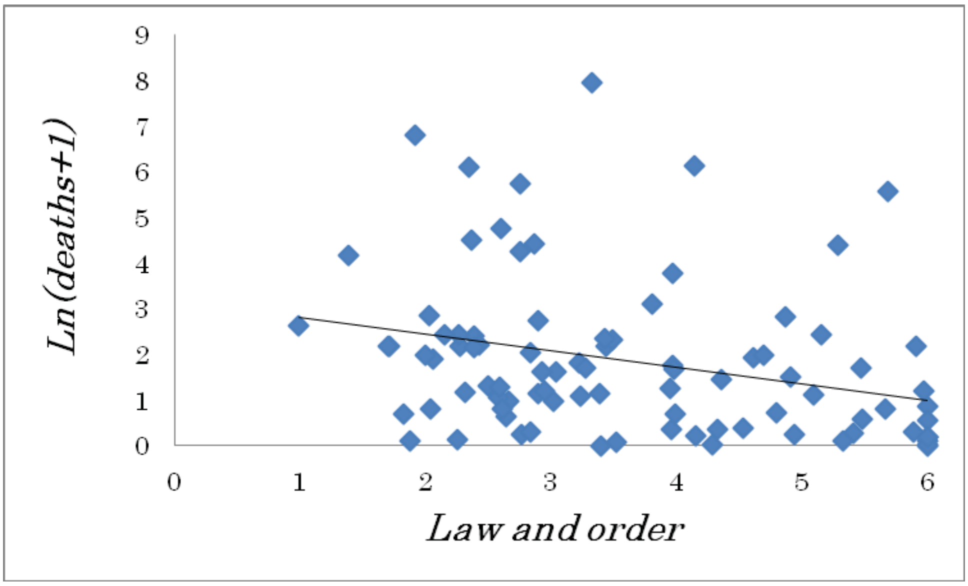

Figure 2. Association between *Law and order* and number of deaths.

Note: Values are average of *ln(deaths)* and that of *Law and order* during 1990-2000 in each country.

Table 1. Definition of variables and their basic statistics

	Definition	Mean	Standard error	Minimum	Maximum
Deaths	Total number of deaths caused by natural disasters	205	1,343	0	21,800
Incorruption	Quality of "public sector" ranges from 0 (corrupted) to 6 (incorrupt)	4.56	1.31	0	6
Law and order	Quality of "law and order" ranges from 0 (poor) to 6 (good)	4.80	1.44	1	6
Decentralization	Share of sub-national (state and local) expenditures (% of total expenditure)	35.4	14.1	1.6	58.7
Ln(GDP)	Logarithm of GDP per capita	9.00	1.18	5.57	10.4
Land	Land size (million km^2)	1.61	2.87	0.05	9.20
Fertility	Fertility rate	2.28	1.00	1.15	6.5
Population	Population (hundred million)	0.51	1.23	0.01	9.70
Openness	Ratio of exports plus imports (% of GDP)	61.5	29.9	12.7	196.2
Ln(Government size)	Ratio of total government expenditure (% of GDP)	2.76	0.38	1.09	3.77
Gini	Gini coefficients	42.9	8.46	21.1	61.8
Ethnic fractionalization	Index of ethnic fractionalization	0.33	0.24	0.01	0.9
Political right	Political rights range from 1 (poor) to 7 (good)	6.30	1.39	1	7
Civil liberty and Political liberty	Average value of *Civil liberty* and *Political liberty* *Civil liberty* (and *political liberty*) ranges from 0 (poor) to 7 (good)	5.37	0.96	1.5	6
Ln(Schooling)	Logarithm of schooling years	2.01	0.39	1.05	2.57

Note: Number of observations is 345, which is used for estimations in columns (1)–(3) of Table 3.

Table 2. Distribution of deaths

Number of deaths	(%)
0	58.7
1–99	26.1
100–999	10.6
1000–4999	2.6
5000–9999	0.5
10000+	0.56

Table 3. Number of deaths by natural disaster and institutional quality (negative binominal model)

	(1)	(2)	(3)	(4)	(5)	(6)
Incorruption	–0.41**	–0.65***		-0.51***	–0.61***	
	(–2.01)	(–3.17)		(-3.61)	(–4.33)	
Legal	–0.68***		–0.91***	-0.50***		–0.61***
	(–2.68)		(–4.05)	(-3.38)		(–4.52)
Decentralization	–0.04**	–0.03*	–0.04**	-0.03**	–0.02	–0.04***
	(–2.27)	(–1.95)	(–2.44)	(-2.10)	(–1.59)	(–3.00)
Ln(GDP)	0.38	0.25	0.51	0.61***	$0.32*10^{-6}$*	0.60**
	(1.08)	(0.61)	(1.36)	(2.77)	(1.67)	(2.56)
Land	0.20**	0.16*	0.19**	0.17***	0.11**	0.18***
	(2.37)	(1.94)	(2.29)	(3.22)	(2.01)	(3.45)
Fertility	–0.90**	–0.35	–1.05**			
	(–2.07)	(–0.89)	(–2.72)			
Population	0.59***	0.56***	0.62***	0.52***	0.35***	0.59***
	(4.76)	(3.72)	(5.28)	(5.43)	(3.86)	(5.58)
Openness	–0.01**	–0.01	–0.01**			
	(–2.18)	(–1.03)	(–2.54)			
Ln(Government size)	–0.54	–0.40	–1.01			
	(–0.69)	(–0.61)	(–1.34)			
Gini	0.02	0.03	0.01			
	(0.74)	(1.09)	(0.50)			
Ethnic fractionalization	2.56**	2.82**	2.70**	3.23***	4.62***	3.28***
	(2.03)	(2.25)	(2.00)	(2.90)	(4.14)	(2.97)
Political right	0.19	0.48*	0.10	0.13	0.20	0.06
	(0.86)	(1.72)	(0.45)	(0.75)	(0.88)	(0.35)
Liberty	–0.89*	–1.43**	–0.83*	-0.56	–0.74	–0.67
	(–1.84)	(–2.06)	(–1.84)	(-1.37)	(–1.47)	(–1.47)
Ln(Schooling)	–0.15	–0.38	–0.31			
	(–0.22)	(–0.50)	(–0.39)			
Trend	–-0.01	–0.04	0.003	-0.0006	–0.03	0.008
	(–0.33)	(–1.33)	(0.09)	(-0.02)	(–1.41)	(0.29)
Constant	11.9***	10.9***	12.4***	3.66	5.53**	3.10
	(3.19)	(2.81)	(3.38)	(1.60)	(2.41)	(1.29)
Log pseudo-likelihood	–1196	–1200	–1199	–1188	–1995	–1995
Observations	345	345	345	539	539	539

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

Table 4. Number of deaths by natural disaster and institutional quality (Tobit model)

	(1)	(2)	(3)	(4)	(5)	(6)
Incorruption	–0.27	–0.43*		-0.39**	–0.48***	
	(–1.20)	(–1.96)		(-2.36)	(–3.13)	
Legal	–0.45		–0.58**	-0.22		–0.38**
	(–1.57)		(–2.15)	(-1.24)		(–2.24)
Decentralization	–0.08***	–0.08***	–0.09***	-0.06***	-0.06***	-0.07***
	(–3.67)	(–3.53)	(–3.92)	(-3.88)	(-3.84)	(-4.47)
Ln(GDP)	0.70*	0.50	0.69*	0.44*	0.28	0.37
	(1.72)	(1.28)	(1.70)	(1.70)	(1.24)	(1.41)
Land	0.30***	0.24***	0.32***	0.30***	0.28***	0.33***
	(3.10)	(2.66)	(3.34)	(4.91)	(4.76)	(5.62)
Fertility	–1.21***	–1.07***	–1.26***			
	(–2.98)	(–2.77)	(–3.13)			
Population	0.88***	0.85***	0.91***	0.73***	0.70***	0.76***
	(7.32)	(6.90)	(7.53)	(8.71)	(8.39)	(8.92)
Openness	–0.01	–0.01	–0.01*			
	(–1.54)	(–1.60)	(–1.65)			
Ln(Government size)	–0.40	–0.42	–0.62			
	(–0.78)	(–0.79)	(–1.31)			
Gini	0.05	0.06	0.04			
	(1.14)	(1.56)	(1.02)			
Ethnic fractionalization	5.75***	6.30***	5.57***	6.32***	6.57***	6.24***
	(4.55)	(5.11)	(4.46)	(7.19)	(7.58)	(7.09)
Political right	0.01	0.02	-0.03	-0.07	-0.02	-0.19
	(0.05)	(0.11)	(-0.15)	(-0.45)	(-0.16)	(-1.32)
Liberty	–0.24	–0.08	–0.31	0.49**	0.50**	0.57***
	(–0.58)	(–0.22)	(–0.77)	(2.38)	(2.42)	(2.74)
Ln(Schooling)	–0.64	–0.71	–0.65			
	(–0.90)	(–0.98)	(–0.92)			
Trend	0.03	0.005	0.04	0.06*	0.05	0.08**
	(0.72)	(0.12)	(0.97)	(1.97)	(1.59)	(2.40)
Constant	1.36	0.57	2.26	-6.03***	-5.19***	-6.28***
	(0.36)	(0.16)	(0.62)	(-3.08)	(-2.76)	(-3.20)
Log pseudo-likelihood	–516	–518	–517	–854	–855	–857
Observations	345	345	345	539	539	539

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

Table 5(a). Number of deaths by natural disaster and institutional quality (negative binominal model): sample of column (1) in Table 3

	(1)	(2)	(3)	(4)	(5)	(6)
*Incorruption*Decentralization*	–0.05***		–0.05***			
	(–3.36)		(–3.88)			
*Incorruption*Decentralization* Ln(GDP)*		-0.006***		–0.005***		
		(-4.32)		(–4.31)		
*Legal*Decentralization*	–0.002				–0.02**	
	(–0.14)				(–2.00)	
*Legal*Decentralization*Ln(GDP)*		0.01				–0.002**
		(1.27)				(–2.15)
Log pseudo-likelihood	–1189	-1185	–1189	–1186	–1194	–1193
Observations	345	345	345	345	345	345

Note: Values in parentheses are z-statistics calculated using robust standard errors. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. All independent variables used in column (1) of Table 3 are also included, but not reported to save space.

Table 5(b). Number of deaths by natural disaster and institutional quality (negative binominal model): sample of column (4) in Table 3

	(1)	(2)	(3)	(4)	(5)	(6)
Incorruption Decentralization*	–0.01		–0.03***			
	(–1.55)		(–3.69)			
*Incorruption *Decentralization* Ln(GDP)*		–0.002*		–0.002***		
		(–1.81)		(–3.25)		
Legal Decentralization*	–0.02***				–0.02***	
	(–2.63)				(–4.33)	
*Legal*Decentralization*Ln(GDP)*		–0.0007				–0.002***
		(–0.88)				(–3.61)
Log pseudo-likelihood	–1977	–1978	–1980	–1979	–1978	–1981
Observations	539	539	539	539	539	539

Note: Values in parentheses are z-statistics calculated using robust standard errors. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. All independent variables used in column (4) of Table 3 are also included, but not reported to save space.

Table 6(a). Number of deaths by natural disaster and institutional quality (Tobit model): sample of column (1) in Table 3

	(1)	(2)	(3)	(4)	(5)	(6)
*Incorruption*Decentralization*	–0.02*		–0.03**			
	(–1.80)		(–2.42)			
*Incorruption*Decentralization* Ln(GDP)*		-0.003**		–0.002**		
		(-2.13)		(–2.58)		
*Legal*Decentralization*	–0.004				–0.01	
	(–0.28)				(–1.60)	
*Legal*Decentralization*Ln(GDP)*		0.001				–0.001
		(0.55)				(–1.49)
Log pseudo-likelihood	–513	-512	–513	–512	–514	–515
Observations	345	345	345	345	345	345

Note: Values in parentheses are z-statistics calculated using robust standard errors. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. All independent variables used in column (1) of Table 3 are also included, but not reported to save space.

Table 6(b). Number of deaths by natural disaster and institutional quality (Tobit model): sample of column (4) in Table 3

	(1)	(2)	(3)	(4)	(5)	(6)
Incorruption Decentralization*	–0.02**		–0.03***			
	(–2.33)		(–3.89)			
*Incorruption*Decentralization* Ln(GDP)*		–0.002**		–0.002***		
		(–2.49)		(–3.99)		
Legal Decentralization*	–0.01				–0.02***	
	(–0.95)				(–3.16)	
*Legal*Decentralization*Ln(GDP)*		0.0002				–0.001***
		(0.22)				(–3.07)
Log pseudo-likelihood	–846	–845	–846	–845	–848	–849
Observations	539	539	539	539	539	539

Note: Values in parentheses are z-statistics calculated using robust standard errors. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. All independent variables used in column (4) of Table 3 are also included, but not reported to save space.

Appendix Table A1. List of countries

	Name of countries	Columns (1)–(3)	Columns (4)–(6)
1	Argentina	###	###
2	Argentina	#	###
3	Australia	###	###
4	Austria	###	###
5	Bolivia	##	###
6	Botswana	#	#
7	Brazil	##	###
8	Canada	###	###
9	Chile	##	###
10	China		##
11	Costa Rica	###	###
12	Denmark		###
13	Dominican	###	###
14	Finland	###	###
15	France	###	###
16	Hungary	###	###
17	Iceland		###
18	India	##	###
19	Indonesia	##	###
20	Ireland	###	###
21	Israel	#	###
22	Italy	###	###
23	Kenya	#	###
24	Malaysia	##	###
25	Mexico	###	###
26	Netherlands	###	###
27	New Zealand	###	###
28	Nicaragua	##	###
29	Norway	###	###
30	Panama	#	###
31	Paraguay	#	##
32	Peru	#	###
33	Philippines	#	##
34	Portugal	###	###
35	South Africa	##	##
36	Spain	###	###
37	Sweden	###	###
38	Switzerland	###	###
39	Thailand	##	##
40	Trinidad & Tobago	#	##
41	United Kingdom	###	###
42	United States	###	###
43	Uruguay	#	###
44	Zimbabwe	#	#

Note: List shows countries used for estimations in each column of Tables 3 and 4. #, ##, and ### denote countries appearing in the sample only once, two to three times, four times or more, respectively.

Table A2. Source of data

	Source
Deaths	EM-DAT (Emergency Events Database)[a]
Incorruption	International Country Risk Guide (ICRG)
Law and order	International Country Risk Guide (ICRG)
Decentralization	IMF's Government Finance Statistics (GFS). [b]
GDP per capita	World Bank (2011)
Land	World Bank (2011)
Fertility	World Bank (2011)
Population	World Bank (2011)
Openness	World Bank (2011)
Government size	World Bank (2011)
Gini	Salvatore (2008)[c]
Ethnic fractionalization	HP of Marta Reynal-Querol[d]
Political right	Freedom house 1996. This was available from Home page of Shleifer, A. used in La Porta et al.(1999)[e]
Civil and political liberty	Freedom house 2001[f]
Schooling years	Easterly and Levine (1997)[g]

Note: With the exception of the World Bank (2011) and ICRG, the data was obtained from the internet as follows:

a. http://www.emdat.be (accessed on June 1, 2011).

b.http://www1.worldbank.org/publicsector/decentralization/fiscalindicators.htm (accessed on February 08, 2012).

c. http://salvatorebabones.com/data-downloads. (accessed on June 1, 2011).

d. http://www.econ.upf.edu/~reynal/data_web.htm (accessed on December 1, 2011).

e. http://www.economics.harvard.edu/faculty/shleifer/dataset (accessed on June 2, 2011).

f.http://www.nationmaster.com/graph/dem_civ_and_pol_lib-democracy-civil-and-political-liberties(accessed on February 15, 2012).

g.http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTRESEARCH/0,,contentMDK:20700002~pagePK:64214825~piPK:64214943~theSitePK:469382,00.html(accessed on June 2, 2011).