Death tolls from natural disasters: Influence of interactions between fiscal decentralization, institution, and economic development

Yamamura, Eiji

22 February 2012

Death tolls from natural disasters: Influence of interactions between fiscal decentralization, institution, and economic development

Abstract

Previous research shows that the effect of decentralization on damage caused by natural disasters will differ according a country's level of economic development. To investigate this matter further, this paper uses cross-country data from 1990 to 2001 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 levels 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.

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

JEL classification: D73; K10; O1; Q54

1. Introduction

Exogenous shocks in modern society can produce a significant impact. A natural disaster is a prime example of a serious exogenous shock, and since the 2000s researchers have paid close attention to the subject from an economic point of view (e.g., Tol and Leek 1999; Horwich 2000; Skidmore and Toya 2002; Sawada 2007; Sawada and Shimizutani 2007; 2008; Strobl 2011a; 2011b). Disaster prevention measures are now provided as a consequence of economic growth. 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). Income is an important factor in reducing damage, but has a very small effect when the scale of a disaster is small (Yamamura 2010). Income inequality increases the death rate in the event of natural disaster (Anbarci et al. 2005). As argued by Albala-Bertrand (1993), the issue of disasters cannot be analyzed in isolation from the particular social and political setting where disasters 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).

The occurrence of natural disasters is not systematically associated with the level of economic development (Kahn 2005). Government is necessarily anticipated to prepare for a natural disaster and to protect people in its event. Quality of governance and government structure can be regarded as the key determinants of reducing the damage of natural disasters.[1] For example, Escaleras et al. (2007) found a relationship between countries with lower levels of corruption and less damage from natural disasters. 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). This is consistent with the argument that local government officials have greater knowledge and understanding of local demand than central government (Treisman 2002). Congruent with these works, empirical evidence based on panel data suggests that decentralization plays a central role in mitigating the damage of natural disasters

[1] 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 the catastrophe that followed Katrina (Congleton 2006).

(Escaleras and Register 2010; Toya and Skidmore, 2010). Fisman and Gatti (2002a) focused on an association between decentralization and corruption and found that decentralization is strongly associated with lower levels of corruption.[2] 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 is considered to make decentralization more effective. The effect of quality of government on natural disaster outcomes appears to be affected by the structure of government. This paper jointly considers the quality of institution and structure of government, as opposed to independently, and focuses on the effect of the interaction between decentralization and institutional quality on natural disasters.

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; and second, the key determinants of damage are different between developing countries and OECD countries. 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.[3] 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. In general terms, prior research has not compared developing and developed countries with regard to the role played by the structure of government and institutional quality in reducing damage from a disaster. Hence, the main purpose of this paper is to scrutinize the mechanism of interaction between institutional setting and economic development on deaths caused by 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 studies show that the levels of damage caused by natural disasters are lower in countries with a more decentralized government. The effect of decentralization is

[2] Fisman and Gatti (2002b) found that the association between decentralization and corruption depends on the degree of devolution of revenue generation to local government.
[3] 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).

greater in countries with less public sector corruption and better functioning legal systems. Furthermore, the interaction between decentralization and institution made a greater contribution to the reduction of deaths in more developed countries. 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 discusses the results of the estimations; and section 5 offers concluding observations.

2. Hypotheses

Corruption is thought to motivate bureaucrats to direct public expenditure through channels that make it easier to collect bribes. Thus, the 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.

It has been recently shown 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). In contrast, in the case that local government attempts to enact legislation to prevent corruption, the formal rule determined by the local government should be obeyed to avoid corruption.

However, people are unlikely to obey the rule, and corruption will continue to be widely practiced. Hence, 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.

However, assuming that there is a lack of appropriate construction engineering, seismically insensitive buildings cannot 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[4] were only available from 1984 to 2010 from the International Country Risk Guide (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

[4] The measure for legal system quality is 'law and order' in the ICRG.

the World Bank (2011). Ethic fractionalization was sourced from HP of Marta Reynal-Querol, and political right was obtained from Freedom House 1996. Data for GINI (income Gini coefficients) was gathered from the Standardized Income Distribution Database (SIDD) developed by Salvatore (2008).[5] 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 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.

With respect to the measures of public sector corruption and the state of legal systems, 'public sector corruption' and 'quality of legal system' values range from 0 to 6. 'Public sector corruption' indicates the likelihood that senior government officials would demand special payments in the form of bribes. Thus, the ICRG corruption index captures financial corruption. 'Quality of legal system' reflects the results of assessments regarding (1) the strength and impartiality of the legal system and (2) popular observance of the law. Larger values indicate less corruption and better legal systems. 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 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 Probit model, the Poisson model is

[5] 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.

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.[6] In line with previous literature, the negative binominal model is used in this paper. The estimated function takes the following form:

$$Deaths_{it} = \alpha_0 + \alpha_1 Corruption_{it} + \alpha_2 Legal_{it} + \alpha_3 Decentralization_{it} + \alpha_4 Ln(\mathrm{GDP})_{it} + \alpha_5 Land_{it} + \alpha_6 Population_{it} + \alpha_7 Openness_{it} + \alpha_8 Ln(Size\ of\ government)_{it} + \alpha_9 Gini_{it} + \alpha_{10} Ethnic\ fractionalization_{i} + \alpha_{11} Political\ right_{i} + \alpha_{12} Liberty_{i} + \alpha_{13} Ln(Scholing)_{i} + \alpha_{14} Time\ trend_{t} + e_{it},$$

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 can be controlled when fixed effects or random effects estimations are conducted. However, fixed effects or random effects methods for a negative binominal model have not been developed,[7] and therefore, in alternative estimations, with the aim of controlling for the unobserved time-invariant features of a country, I also used a random effects Tobit model, which was also used by Toya and Skidmore (2010).

The higher the quality of institution, the lower the level of damage from natural disasters. Therefore, I predict the coefficients for *Corruption* and *Legal* to take the

[6] Log(1+deaths) or Log(1+death rate) has been used as a dependent variable in previous research (e.g., Kahn 2005; Escaleras and Register 2010; Toya and Skidmore 2010). This can attenuate the over-dispersion of number of deaths. 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).

[7] Unobserved time-invariant features of a country can be controlled for when country dummies are included in the negative binominal model. Nevertheless, this estimation could not be conducted because a maximum likelihood estimation of a negative binominal model cannot converge when country dummies are included.

negative sign. If decentralization reduces the number of deaths from natural disasters, the coefficient of *Decentralization* will take the 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 *Corruption* and *Decentralization* (and *Legal* and *Decentralization*) were included as independent variables. If *Hypothesis 1* is supported, their coefficients take the negative sign. In addition, with the aim of examining *Hypothesis 2,* these interaction terms were further interacted with *Ln*(GDP). That is, *Corruption* Decentralization* Ln(GDP)* and *Legal* Decentralization* Ln(GDP)* were incorporated. If *Hypothesis 2* is supported, their coefficients take the negative sign.

In addition to *Corruption*, *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.[8] *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 primary model are exhibited in Table 3. Tables 4(a), (b) and (c) present the estimation results of key interaction terms such as Corruption*Decentralization and Legal*Decentralization. In each table, the results of the estimation including all control variables are shown in columns (1)–(3), whereas those where some variables were omitted to increase observations are shown in columns (4)–(6). However, only the results of key interaction term variables are reported in Tables 4(a), (b), and (c) although other control variables used in column (1) of Table 3 are included in all estimations of Table 4(a), and other control variables used in columns

[8] 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.

(4) of Table 3 are included in all estimations of Tables 4(b) and (c). Further, Tables 3, 4(a) and (b) present the results of the negative binominal model, while Table 4(c) presents the results of the random effects Tobit model to check the robustness of the results when the time invariant features of countries are controlled for.

I begin by interpreting the results of Table 3. As expected, *Corruption* 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. 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.

I now turn to the key interaction terms presented in Table 4(a). I see from column (1) that *Corruption*Decentralization* yields the negative sign and is statistically significant at the 1% level, whereas *Legal*Decentralization* produces the negative sign and is not statistically significant. The correlation coefficient between *Corruption* and *Legal* is 0.71 at the 1% level. Hence, there is the possibility that collinearity between them has 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

Corruption and *Legal* are included separately. In column (3), the coefficient of *Corruption*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 *Corruption*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.*

The results of Table 4(b) are very similar to those shown in Table 4(a), which are consistent with *Hypothesis 1* and *2*. As exhibited in Table 4(c), I now look at the results of the random effects Tobit model using the same sample as in Table 4(b). Columns (1) and (2) in Table 4(c) show that the variables' coefficients do not yield significant signs although they are the predicted negative signs. However, I see from columns (3)–(6) that all coefficients continue to take the negative sign and become statistically significant. As shown in columns (3) and (5), the absolute values of *Corruption*Decentralization* and *Legal*Decentralization* are 15.1 and 13.9, respectively. In contrast, as presented in columns (4) and (6), those of *Corruption*Decentralization*Ln(GDP)* and *Legal*Decentralization*Ln(GDP)* are 1.72 and 1.39, respectively. They are distinctly larger than those corresponding values in Table 4(b), which are less than 0.01. This may be because the estimation results of Table 4(c) are influenced by the over-dispersion of the dependent variable. Hence, the magnitude of each interaction term is thought to suffer from upward bias. All in all, however, the results of each interaction variable are robust to the alternative specifications. The joint consideration of Tables 3, 4(a), (b), and (c) reveals that *Hypothesis 1* and *2* are strongly supported.

The enforcement of property rights shapes the basic incentive structures of an economy. According to North (1990), "even when efficient property rights are derived, they will still typically have features that will be very costly to monitor or enforce, reflecting built-in disincentives or at the very least aspects of the exchange that provide temptation to renege, shirk, or cheat. In many cases informal constraints will evolve to mitigate disincentive consequences" (North 1990, p. 110). As argued previously (Greif 1994; Hayami 2001), the informal institution based on a norm obeyed by a member of the community plays a critical role in preventing opportunistic behavior because of the fear of ostracism when the transaction is limited to a community member. However, the effectiveness of the norm is limited to the member of the closed community and its

importance will decline in the process of economic development. Compared with an informal institution, the formal institution is based on a legal system, which acts effectively for a non-community member, and has become more important as market transactions have become more widespread with economic development. In short, the role of the informal institution is more important in developing countries, whereas the role of the formal institution is more important in developed countries. The evidence provided in this paper is consistent with this view. However, 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.

5. Conclusions

Previous studies have suggested that the determinants of damage caused by natural disasters are different between developing and developed countries (Toya and Skidmore 2007). The level of economic development can be captured not only by per capita GDP, but also by political condition. However, little is known regarding what factors cause this difference in damage levels between developing and developed countries. With the aim of identifying these factors, this paper used cross-country data from 1990 to 2000 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.

The essential technology required to reduce the impact of natural disasters is more likely to exist in developed countries than in developing nations. When essential technology does not exist, quality of institution plays only a minor role in the mitigation of damage in the event of a natural disaster. If this holds true, from what has been shown in this paper, I derive the argument that institutional and political systems become more important to ensure the effective of essential technology. If technology is

considered to be an input of production, such as educated workers, then it is similar to the view that "the ability of local government to operate effectively and thus produce a safer environment is greatly enhance by having an educated work force from which to hire capable public employees" (Toya and Skidmore 2010, p. 51). Furthermore, it is necessary to consider political institutions as a whole in an attempt to design an effective disaster prevention measure. That is, I found it critical to investigate the interaction between the institutional factors captured by, for instance, decentralization, corruption, and legal quality. The effectiveness of decentralization greatly depends on institutional circumstance. Further, contrary to previous research that suggested that decentralization is not important in reducing the number of deaths from disasters in developed countries (Escaleras and Register 2010), institutional quality is considered to play an important role in both developing countries and in developed countries in an attempt to cope with unforeseen disastrous events. The findings in this paper show that disaster prevention technology makes a greater contribution to mitigating the damage of natural disasters when governments are more decentralized and less corrupt, and that a well-functioning legal system exists. From this, I draw the policy implication that the transfer of disaster prevention technology should be extended to more decentralized countries if institution is well established.

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.

References

Anbarci, N., Escaleras, M., Register, C. 2005. Earthquake fatalities: the interaction of nature and political economy. Journal of Public Economics 89, 1907–1933.

Albala-Bertrand, J. (1993), Political Economy of Large Natural Disasters, Oxford University Press, Inc., New York.

Congleton, R.G. (2006). The story of Katrina: New Orleans and the political economy of catastrophe. Public Choice 127, 5-30.

Easterly, W., Levine, R. (1997). Africa's growth tragedy: Policies and ethnic divisions.Quarterly Journal of Economics 112: 1203-50.

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

Escaleras, M., Register, C. (2010). Fiscal decentralization and natural disaster risks. forthcoming in Public Choice.

Fisman, R., Gatti, R. (2002 a). Decentralization and corruption: evidence across countries. Journal of Public Economics 83: 325-345.

Fisman, R., Gatti, R. (2002 b). Decentralization and corruption: Evidence from U.S. federal transfer programs. Public Choice 113: 25-35.

Greif, A. (1994.) Cultural belief and the organization of society: a historical and theoretical reflection on collectivist and individualist societies, Journal of Political Economy 102, 912-950.

Hayami, Y. (2001). Development Economics: From the Poverty to the Wealth of Nations. Oxford University Press, New York.

Horwich, G. (2000). Economic lessons from the Kobe earthquake, Economic Development and Cultural Change 48: 521-542.

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.

Kellenberg, D., Mobarak, A. (2008). Does rising income increase or decrease damage risk from natural disasters? Journal of Urban Economics 63: 788-802.

La Porta, R., Lopez de Silanes, F., Shleifer, A., Vishni, R. (1999). Quality of government. Journal of Law, Economics and Organization 15(1), 222–279.

Mauro, P. (1995). Corruption and Growth. Quarterly Journal of Economics 110, 681–712.

Mill, J. 1977. De Tocqueville on democracy in America. In J. Robson (eds), Collected works. University of Toronto Press, Toronto.

North. D., 1990. Institutions, Institutional Change and Economic Performance.

Cambridge University Press, Cambridge.

Panizzi, U. (1999). On the determinants of fiscal centralization: theory and evidence. Journal of Public Economics 74, 97-139.

Salvatore, B. 2008. Standardized income inequality data for use in cross-national research. Sociological Inquiry 77, 3–22.

Sawada, Y. (2007). The impact of natural and manmade disasters on household welfare. Agricultural Economics 37, 59–73.

Sawada, Y., Shimizutani, S. (2007). Consumption insurance against natural disasters: evidence from the Great Hanshin-Awaji (Kobe) earthquake. Applied Economics Letters 14(4–6), 303–306.

Sawada, Y., Shimizutani, S. (2008). How do people cope with natural disasters? Evidence from the great Hanshin-Awaji (Kobe) earthquake in 1995. Journal of Money, Credit and Banking 40(2–3), 463–488.

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

Shughart II., W.F. (2006). Katrinanomics: The politics and economics of disaster relief. Public Choice 127, 31-53.

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

Sobel. R.S., Leeson, P.T. (2006).Government's response to Hurricane Katrina: A public choice analysis. Public Choice 127, 55-73.

Strobl, E. (2011 a). The economic growth impact of hurricanes: Evidence from U.S. coastal countries. Review of Economics and Statistics 93(2), 575–589.

Strobl, E. (2011 b). The economic growth impact of natural disasters in developing countries: Evidence from hurricane strikes in the Central American and Caribbean regions. Journal of Development Economics, 97, 130–141.

Swaleheen, M. (2011). Economic growth with endogenous corruption: an empirical study. Public Choice 146(1), 23–41.

Tanzi, V., (1995). Fiscal federalism and decentralization: a review of some efficiency and macroeconomic aspects. in World Bank, annual World Bank conference on development economics 1995. Washington, C., The world Ban..

Tanzi, V., (2002). Corruption around the world: causes, consequences, scope, and cures, in Abed, G.T., Gupta, S (Eds.), Governance, Corruption, & Economic Performance. International Monetary Fund., Washington, D.C., 19-58.

Tanzi, V., Davoodi, H. (1997). Corruption, public investment, and growth. IMF working paper WP/97/139.

Tanzi, V., Davoodi, H. (2002).Corruption, growth, and public finance, in Abed, G.T., Gupta, S (Eds.), Governance, Corruption, & Economic Performance. International Monetary Fund., Washington, D.C., 197-222.

Tol, R., Leek, F. (1999). Economic analysis of natural disasters. in T. Downing, A. Olsthoorn, and R. Tol, eds, Climate Change and Risk, Routledge, London.

Toya, H., Skidmore, M. (2007). Economic development and the impacts of natural disasters. Economics Letters 94(1): 20-25.

Toya, H., Skidmore, M. (2010). Natural disaster impacts and fiscal decentralization. CESifo Forum 11(2): 43-55.

Treisman, D. (2002). The causes of corruption: a cross-national study. Journal of Public Economics 76, 399-457.

Wooldridge, J. (2002). Econometric analysis of cross section and panel data. Cambridge, MA: MIT Press.

World Bank. (2011). World Development Indicators 2011 on CD-ROM. The world Bank.

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.

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
Corruption	Quality of "public sector" ranges from 0 (corrupted) to 6 (less corrupt)	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 right ranges 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)
Corruption	–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(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)
*Corruption*Decentralization*	–0.05***		–0.05***			
	(–3.36)		(–3.88)			
*Corruption*Decentralization* Ln(GDP per capita)*		-0.006***		–0.005***		
		(-4.32)		(–4.31)		
*Legal*Decentralization*	–0.002				–0.02**	
	(–0.14)				(–2.00)	
*Legal*Decentralization*Ln(GDP per capita)*		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 4(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)
Corruption Decentralization*	–0.01		–0.03***			
	(–1.55)		(–3.69)			
*Corruption*Decentralization* Ln(GDP per capita)*		–0.002*		–0.002***		
		(–1.81)		(–3.25)		
Legal Decentralization*	–0.02***				–0.02***	
	(–2.63)				(–4.33)	
*Legal*Decentralization*Ln(GDP per capita)*		–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 4(c). Number of deaths by natural disaster and institutional quality (random effects Tobit model): sample of column (4) in Table 3

	(1)	(2)	(3)	(4)	(5)	(6)
Corruption Decentralization*	–8.45		–15.1**			
	(–0.96)		(–2.00)			
*Corruption*Decentralization* Ln(GDP per capita)*		–1.17		–1.72***		
		(–1.24)		(–2.64)		
*Legal*Decentralization*	–10.1				–13.9**	
	(–1.39)				(–2.25)	
*Legal*Decentralization*Ln(GDP per capita)*		–0.64				–1.39**
		(–0.79)				(–2.44)
Log likelihood	–2614	–2613	–2615	–2614	–2614	–2614
Observations	539	539	539	539	539	539

Note: Values in parentheses are z-statistics. *, **, 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]
Corruption	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)[e]

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).

ま n mamam