THE SHOCKING ORIGINS OF POLITICAL TRANSITIONS? EVIDENCE FROM EARTHQUAKES*

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Running Head: The Shocking Origins of Political Transitions?

Abstract

Do earthquakes trigger political transitions? Using a rich panel dataset of 160 countries observed over 1950 to 2007, we find that earthquake shocks, measured in terms of the effect of ground-motion amplitude on death toll, have two contradicting effects on political change. On the one hand, earthquakes drive transitions into democracy due to an affective shock, which we interpret to be the reaction of voters to earthquakes by which they hold the incumbent government responsible for earthquake damages. On the other hand, earthquakes indirectly hasten transitions into a less democratic regime because they increase the income level contemporaneously, possibly due to short-term emergency response and recovery expenditures, and thus, making it costlier to contest the incumbent government. Overall, we show that, while not leading to a full-fledged regime transition, earthquake shocks open a new democratic window of opportunity, but this window is narrowed by improved economic conditions.

Keywords: Earthquake shocks, autocracy, democracy

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1. Introduction

Do earthquakes trigger political transitions? History portrays numerous tragic earthquakes that not only reshaped geographical settings, but also realigned the political powers within countries. Many ancient cities, including Herculaneum and Pompeii in Italy, Sodom and Gomorrah in modern-day Jordan, Bura and Helice in Greece, Lima in Peru, Copiapo in Chile, among others, faced catastrophic destruction caused by earthquakes that in turn changed the political balances of the then period (Boscowitz and Pitman 1890).

In the modern era, earthquakes have occurred frequently without changing the topographic structure (e.g., Peru in 1970, China in 1976, Mexico in 1985, Armenia in 1988, the United States in 1989, Iran in 1990, Japan in 1995, Turkey in 1999, Indonesia in 2004 and Haiti in 2010). Nonetheless, they have caused massive human and physical damages in a greater proportion than that of ancient times. On average, approximately 1.4 million earthquakes occur in a year around the world (USGS 2014). Between 1950 and 2009, the earth quaked *catastrophically* around 570 times not only killing over two million people but also affecting over 300 million people in total (EM-DAT 2011).

Drastic changes in economic conditions triggered by earthquakes, such as altered income levels, investment, and the distribution of resources in the emergency response and recovery process, may affect the fate of the incumbent regime (Leeson and Sobel 2011). Such possibility of political change has also been endorsed by the meteoric rise in the number of studies exploring political transitions sparked by dramatic changes in economic conditions (*see* Lipset 1959; Acemoglu and Robinson 2001).

In a similar vein, a burgeoning literature explores the influence of climatic, topographic, and more generally, geographic conditions on political outcomes. For instance, Brückner and Ciccone (2011) find that lack of rainfall in Sub-Saharan Africa, through causing an economic downturn, led to transitions towards democracy. The theoretical background of these findings is rooted in the work of Acemoglu and Robinson (2001), who predict that, in times of turmoil, pro-democratic masses may revolt against the incumbent autocratic regimes (which are typically supported by the elite) if the opportunity cost of doing so is sufficiently low. Facilitated by the underlying imbalance in political and economic power and due to reduced incomes (at least in the short run), such turmoil may lead to greater demand for democracy. Another strand of literature shows that natural disasters lead to political change due to the corruption triggered by disaster-induced resource windfalls (*see* Leeson and Sobel 2008 for the US, and Yamamura 2014 for the rest of the world). Consistent with the democratic efficiency theory, such public corruption may result in democratic change where voters successfully remove ineffective political agents from office. Leeson and Sobel (2011) provide an empirical evidence for this theory in the case of mayoral elections in New Orleans following Hurricane Katrina.

This paper contributes to the above line of research by investigating the impacts of earthquakes on democratic conditions. The principal link between this study and the afore-mentioned papers is that the turmoil ignited by earthquakes may trigger political change. We differ from the extant work in two respects. First, we focus on earthquakes, which are catastrophes that result in deaths and various types of destructions, with potential long-lasting consequences through economic and political turmoil that might follow. In this way, we also contribute to the scarce literature on the political economy of earthquakes studying their consequences on different outcomes (*see*, notably, Kahn 2005; Anbarci, Escaleras, and Register 2005; Keefer, Neumayer, and Plümper 2011). Second, we distinguish between the 'direct' and 'indirect' effects of earthquakes on political change. That is, we not only study the income (i.e., indirect) channel of earthquakes in line with some studies above, but also consider the direct effect of earthquakes. We interpret the direct effect to be the affective shock experienced by citizens due to the catastrophe. This sort of reaction may originate from sudden and unanticipated nature of earthquakes, which, unlike other catastrophes, come without early warning. The psychological trauma thus caused may lead the voters to punish the incumbent regime. We offer an empirical test of this affective shock effect, and show that it is key to understanding the true impact of earthquakes on political change. Together the affective shock and income effects cover the two major groups of incumbent responsibility ensuing a disaster. That is, people's affective behavior is a function of emergency response and relief activities, and the income effect is a function of government efforts in post-earthquake response and recovery.

Using the ground-motion amplitude derived from the Richter scale to explain earthquake fatalities, we find that the affective shock due to earthquakes is associated with a democratic improvement. This result suggests that voters hold the incumbent government responsible for earthquake damages. We document evidence for two mechanisms through which affective shock becomes instrumental for democratic improvement ensuing earthquakes; when there are national elections in proximity, and when the extent of insured disaster risk in the country is low. Our results also show that earthquake fatalities are associated with higher income, but that, in turn, is associated with lower democracy. We document one mechanism through which the level of income increases ensuing earthquakes; financial stimulus due to post-disaster emergency response and recovery expenditures. The reduced democracy following higher income can sound surprising, but suggests that earthquake-induced higher income raises the opportunity cost of citizens in affective shock to contest the incumbent regime, a prediction that is in line with the political transitions theory of Acemoglu and Robinson (2001). The net finding in our analysis is that, while not leading to a full-fledged political transition, earthquakes open a democratic window of opportunity, but this window is narrowed by improved economic conditions. In partially democratic countries, this effect corresponds to an improved democracy score of 4.6 points in the Polity scale of [–10, 10] for one thousand deaths in every one million people. Although we cannot claim that our main result is strictly causal, it represents a strong correlation that is robust to different samples and alternative approaches in empirical investigation.

Figure 1 illustrates the connection between earthquakes and democracy graphically, portraying a significant link between earthquake death toll and democratic conditions. Higher death toll is mostly associated with partially democratic nations with comparatively lower GDP per capita, while democratic countries with a higher GDP per capita seldom face deaths from earthquakes. Thus, the way earthquakes alter the political landscape is a fruitful question.

The rest of the paper is organised as follows. Section 2 provides some theoretical underpinnings for the relationships explored. Section 3 describes the data. Section 4 presents the estimation methodology. Section 5 discusses the results and reports the robustness checks. Section 6 identifies the mechanisms at work, and section 7 concludes.

2. Earthquakes, Income and Political Change

Although several studies highlight the nexus between earthquakes and economic conditions (Cavallo, Powell, and Becerra 2010), only a few studies mention the relationship between earthquakes and political change (*see* Anbarci, Escaleras, and Register 2005; Keefer, Neumayer, and Plümper 2011). No study, to our knowledge, has hitherto pursued the link between earthquakes and democratic change in a systematic fashion. This section spells out the two potential avenues that could connect earthquakes and democratic change: i) affective shock of the citizens that may arise just after the disaster, and ii) altered level of income.

2.1. *The Affective Shock Effect of Earthquakes on Democracy*

The first leading channel through which earthquakes may affect political regimes is the human mind. Earthquakes, unlike many other catastrophes, come without early warnings. Consequently, their psychological impacts —especially post-traumatic stress disorder—are enormous (*see* Neria, Nandi, and Galea 2008). Underlying the psychological shock is necrophobia, the fear of death, which is inherent in most adults. Earthquakes represent a sudden and unexpected arrival of the probability of death. Although one may escape death in an earthquake, anxiety triggered by the incident may remain extremely high.[1] Such anxiety may also be deepened by earthquake-related news in the media. In post-earthquake trauma individuals tend to hold the incumbent regime accountable not only for lack of emergency response and recovery, but also for not reducing earthquake risks beforehand. If the government fails to address the pre-earthquake risk

[1] These may even trigger dissociative reactions—including derealisation and depersonalisation and alterations in cognition, among others—among earthquake victims (Cardeña and Spiegel 1993; Helton, Head, and Kemp 2011).

reduction to the degree expected by the majority, people's confidence in the incumbent regime may drop sharply. We argue that the direct impact of earthquakes provides an opportunity to test the voter reaction under psychological trauma as directed towards the incumbent. This argument parallels a recent evidence which shows that voters may punish incumbent governments for events beyond their control (e.g., Cole, Healy, and Werker 2012).

Drury and Olson (1998) document anecdotes that depict the direct effect of earthquakes. For example, the failure of autocratic regime of Guatemala to conduct emergency response and recovery activities after the catastrophic earthquake in 1976 initiated a transition toward a more democratic leadership in the regime. At the other extreme, natural disasters may lead to autocracies. The destructive Hurricane San Zenon, which struck the Dominican Republic in 1931, gave an opportunity to Rafael Trujillo to capitalize on people's positive sentiments on effective disaster management, and establish an autocratic regime that ultimately became one of the worst and longest-lasting dictatorships in the Western Hemisphere.[2]

Although there is overall a stronger indication for democratic improvement due to affective shock of earthquakes, the way in which citizens respond to natural disasters depends also strongly on the incumbent government's facility or lack thereof in supplying relief, and more generally, in coping with the catastrophic event. This degree of facility is endogenous to prevailing political institutions, such as the degree of decentralization of decision-making; *see*, for example, Escaleras and Register (2012).

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[2] The Haiti earthquake in 2010 claimed over 222,500 lives and marked several failures of the Haitian government in post-disaster response. Consequently, people elected the pop-star Michel Martelly as their president.

2.2. *The Income Effect of Earthquakes on Democracy*

An important question is whether the affective shock effect of earthquakes on democracy can be augmented or offset by other factors. Several considerations suggest income to be a potential candidate. In what follows we elaborate how the income channel can operate in this setting.

2.2.1. *The Pure Income Effect of Earthquakes*

The effect of natural disasters on the economy has been widely debated. One school of thought, relying on the celebrated Schumpeter's (1942) 'creative destruction' hypothesis, argues that, in the long-run, the rebuilding effect of natural disasters positively impacts on the economy. Skidmore and Toya (2002), Cuaresma, Hlouskova, and Obersteiner (2008), and Loayza et al. (2012) have all presented evidence in favour of this hypothesis. In the short-run, post-disaster response expenditures may boost the economic activity through public or private cash or in-kind assistance, cleaning up the debris, technology transfer, and short-run investment stimulus.

A different school of thought, namely, Bastiat's popular 'broken window' hypothesis, presents a contrasting view about the effect of natural disasters, pointing to potentially a negative impact. Bastiat (1848) argues that opportunity costs of funds spent to replace a broken pane of glass are unlikely to exceed the gains. This implies a net negative impact of natural disasters on the economy. Felbermayr and Gröschl (2014) provide empirical support for the negative effect.

2.2.2. *Earthquake-Induced Changes in Income and Democratic Conditions*

As with disasters and income, the link between income and political conditions is inconclusive too. Lipset (1959) shows a positive connection between income and democracy, which is termed as 'modernisation theory'. *See* also Epstein et al. (2006). However, challenging the modernisation theory, Przeworski et al. (2000), and Acemoglu et al. (2008) argue that an increase in income does not necessarily result in higher democracy. Acemoglu and Robinson's (2001) theory of political transitions stipulate that transitory negative income shocks may open a democratic window of opportunity, because the cost of contesting the incumbent power in that situation is relatively low. Brückner and Ciccone (2011) find empirical evidence for this argument in the context of Sub-Saharan Africa.

In our setting, whether and how earthquake-induced income changes are associated with democratic conditions is ambiguous. In many countries, earthquakes trigger expenditures on emergency response and humanitarian assistance. The resulting injection of funds can boost income. If such a boost leads countries to embark on a long-run recovery trajectory, then the resulting creative destructive effect can elevate the income level, which may be followed by better democracy as per the modernization theory. However, if the income is altered by post-disaster emergency response efforts only in the short-run, then the increased income may simply raise the opportunity cost of contesting the incumbent, as per the political transitions theory of Acemoglu and Robinson (2001). Crucially, in the former case, higher income will augment the affective shock effect on democracy, while in the latter it will play an offsetting role.

In the other extreme, if the financial response to earthquakes is weak, as would be in countries with low-income regime, then the overall income effect of earthquakes may remain negative due to the destruction. This reduced income would kick in an opposite chain of impact on democracy compared to above, and whether the reduction in income is transitory or more permanent would ultimately determine the final effect on democracy.

3. Data and Measurement

We employ the Emergency Disasters Database (EM-DAT) in our analysis. EM-DAT defines natural disaster as a 'serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses that exceed the ability of the affected community or society to cope using its own resources'. The database makes an entry if a disaster event satisfies any one of the following conditions: (i) 10 or more reported killed; (ii) 100 people reported affected; (iii) a call for international assistance; (iv) a declaration of a state of emergency. These low thresholds guarantee that most natural disasters, including earthquakes, are recorded. The EM-DAT database provides data on total death toll, the number of injured and affected, as well as the Richter scale magnitude of earthquakes.

We measure the physical strength of earthquakes with ground motion amplitude (*GM*). *GM* is constructed out of the Richter scale magnitude by applying the formula $\sum_{i=1}^{n} A_i = \sum_{i=1}^{n} 10^{(RichterScaleMagnitude-5)}$, where *A* stands for ground-motion amplitude from zero (i.e., epicentre) to peak (i.e., earth surface) and *i* for each earthquake. *See* Richter (1935). *GM* allows for aggregating different earthquakes within a year. The same aggregation would not be appropriate for the Richter scale measure, which is based on a logarithmic base 10, where a small increase in the scale implies a large increase in its impact magnitude. Following Keefer, Neumayer, and Plümper (2011), we drop all earthquakes with a magnitude below five. As per the earthquake toll, we take the annual sum of death toll and total affected at the country level if multiple earthquakes exist in a given year. This aggregation strategy is unlikely to affect our estimates, *see* Keefer, Neumayer, and Plümper (2011).

We adopt the *Polity2* to measure the quality of democracy. We utilize it in continuous form, rather than in binary form, to gauge the extent of the change in democratic conditions. Appendix A1 provides the sources and definitions of other data, while Table 1 presents the summary statistics of variables used. Appendix A2 lists the countries included in the sample.

4. Econometric Framework

4.1. Single Equation Estimation

We commence with a standard single-equation specification in which we model the effect of earthquake intensity on the level of democracy:

$$Polity2_{i,t} = C_i + \omega_i t + \delta_t + \lambda_1 logGM_{i,t} + v_{i,t}$$

where *i* stands for country and *t* for time, $(logGM)$ is the log of ground motion amplitude and *Polity2* is the democracy score. Country fixed effects (C), country-specific time trend $(\omega_i t)$, and common time effects (δ) are all controlled for in the model.

This model estimates the net total effect of earthquake intensity on the level of democracy. Although $logGM$ is completely exogenous in this setting, its total effect includes both the direct and the channel effects instigated by an earthquake. These effects may differ in sign. One can control for the potential channel variables such as income in the model, but then that model would not explicitly show how the earthquake damages affected income itself and how the damages come into existence in high- vs. low-income regimes. On the whole, the single-equation approach captures only the unidirectional effects in a reduced-form setting, and is not flexible enough to allow for feedback mechanisms that may play important roles in the final outcome.

4.2 *The System of Simultaneous Equations*

To track the affective shock and the income effects of earthquakes on democratic conditions, we next formulate a three-equation system of simultaneous equations. The principal advantage of this system is that it explicitly allows for modelling certain feedback mechanisms that may be triggered by earthquakes. Specifically, using Three-Stages-Least Squares (3SLS), we estimate:

$$(1) \quad Death_{i,t} = \alpha_i + \rho_i t + \emptyset_t + \beta_1 logGM_{i,t} + \beta_2 \, logy_{i,t} + \beta_3 \, logy_{i,t}^2 + \varepsilon_{i,t}$$

$$(2) \quad logy_{i,t} = \partial_i + \varphi_i t + \theta_t + \gamma_1 Death_{i,t} + \gamma_2 logNY_{i,t} + \vartheta_{i,t}$$

$$(3) \quad Polity2_{i,t} = \complement_i + \omega_i t + \delta_t + \lambda_1 logy_{i,t} + \lambda_2 Death_{i,t} + \lambda_3 NP_{i,t} + \upsilon_{i,t}$$

with country-specific fixed effects $(\alpha, \partial, and\ \complement)$, country-specific time trend $(\rho_i t, \varphi_i t\ and\ \omega_i t)$, and common time-varying shocks that affect all countries $(\emptyset, \theta\ and\ \delta)$ are all controlled in three equations of the system.

Equation (1) of the system captures the relationship between $(logGM)$ and the earthquake mortality normalised by population $(Death)$. We consider $Death$ as a proxy for earthquake destruction, capturing the relevant human as well as physical damages. In other words, we model the fact that it is not the earthquakes that kill people, but collapsed buildings and physical infrastructure. Thus, the higher is $Death$, the higher the human and physical damage. Importantly, equation (1) also controls for log income per capita and its quadratic $(logy$ & $logy^2)$. This is to model the degree of destruction in different income regimes, because, for example, an earthquake with Richter scale of seven does not result in the same destruction in Japan and Turkey. The impact of natural disasters largely depends on the preparedness levels and risk-mitigation plans in countries (such as construction codes and building quality), and hence, the quadratic income specification can proxy this differential (*see* Noy 2009). Lastly, estimation of a system of simultaneous equations requires a distinct explanatory variable for each equation to meet the rank and order condition. For equation (1), this variable is $(logGM)$.

Equation (2) of the system captures the effect of earthquake damages on $logy$, with $Death$ utilized as explanatory variable. As mentioned in section 2.2.2, the sign of the effect of *Death* on *logy* is likely to be determined by the extent of injection of funds into the economy following the disaster. A different question is whether the relationship between *Death* and *logy* captures a short term emergency response and recovery mechanism or a longer term creative destruction mechanism. In a preliminary analysis, we explore the lag effects of $Death$ on $logy$ using its three lags, and estimate all the lagged terms to be insignificant (*see* Appendix A3). By contrast, we always estimate the contemporaneous relationship between $Death$ and $logy$ to be significant and positive. Thus, we consider the significant and positive effect $Death$ on $logy$ in a given year as a support for the emergency response and recovery mechanism in the short-run, and from now on, take it as granted that earthquakes increase income, and they do so only contemporaneously. Equation (2) also includes log weighted-income of bordering countries as the distinct exogenous variable for system identification. Several studies suggest that countries with open, large and developed neighbours grow faster than those with closed, smaller and less developed neighbours (*see* Ramon and Trehan 1997; Ades and Chua 1997).

Finally, equation (3) of the system captures the effect of $Death$ and $logy$ on democracy $(Polity2)$. As indicated above, we interpret the (non-income) direct effect of $Death$ as the citizens' reaction to the incumbent regime ensuing the disaster. This effect is likely to be driven by a shocked state of the human mind whereby greater earthquake-related deaths and physical destruction, which the citizens perceive to have happened due to the government's failure in the pre-disaster phase and its poor intervention strategies in the emergency response stage, can drive a strong reaction. Our interpretation of this effect as the 'shock' effect is also facilitated by the fact that greater ground-motion amplitude means greater destruction, greater affective shock, and thus, greater reaction to the concomitant death toll and physical damages. Several robustness checks and falsification tests presented below yield strong evidence that interpreting this direct effect as the shock effect is plausible. In this equation, $logy$ captures the income effect of earthquakes on democracy. This equation also includes the weighted average Polity2 score of neighbouring countries (NP) as the distinct explanatory variable needed to identify the system.[3] The relevance of this variable for $Polity2$ is well established in the democratic domino theory.

All the three equations in the system control for the country-specific fixed effects, country-specific time trends and common time effects. Such a restrictive specification is unlikely to pick up spurious effects. In addition, with the use of fixed effects and country-specific time trends, our models capture not only the deviations 'from within-country means', but also deviations of 'relationships outside their country-specific long-run path'. For neighbors' variables, recent history demonstrates what may be an extreme but a highly illustrious example of this sort of spurts: the recent Arab Spring represents deviations from the long-run political trajectories in the Middle East, as initiated by Tunisia, later followed by Egypt, Libya and Syria.

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[3] Our neighbors' size measure is GDP. Two alternative size measures, surface area and population, yield similar results for the main effects in equations (1), (2) and (3).

4.3. *Potential Caveats Against System Identification*

4.3.1. *Ground Motion Amplitude*

While it is plausible to argue that $logGM$ is exogenous, it must also be distinct to equation (1) to satisfy the system identification. Our assumption is that $logGM$ affects $logy$ and $Polity2$ only through *Death* it provokes. One may argue that earthquakes could also trigger physical capital investment beyond the effect that would be caused only by *Death*. We explore such possibility by regressing gross capital formation on $logGM$, as well as on *Death* instrumented with $log\ GM$. Appendix A4 shows no statistically significant relationship between earthquakes and physical capital formation. While this finding should not immediately discard the role for investment in the post-disaster phase, it is comforting for the identification of system at hand that is based on annual panel data. Nonetheless, this restriction may be violated in longer term.[4, 5]

4.3.2. Neighbours' Income and Polity

Using neighbours' characteristics as source of exogenous variation is not rare in comparative economic growth (e.g., Ramon and Trehan 1997; Ades and Chua 1997) and political economy literatures (e.g., Starr 1991; Leeson and Dean 2009). The arguments are based on the fact that countries with open, large, developed and democratic neighbours grow and democratise faster than those with closed, smaller, less developed, and nondemocratic neighbours. Leeson, Sobel,

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[4] Admittedly, physical capital formation may not include all the relevant types of capital, or a negative effect in some types of capital may be offset by a positive effect in other types of capital.

[5] Another threat to identification is that the larger population density implied by urbanization could increase the reported earthquakes fatalities. Controlling for income and its quadratic in equation (1) would capture this effect.

and Dean (2012) indicate that the spill-over effects of capitalism and democracy across countries take place at approximately the same rate.

Our key assumption in using the bordering countries' income and democracy as distinct exogenous variables in the simultaneous equations system is that country-fixed effects, year-fixed effects and country-specific time trends in equations (1) to (3) capture a wide range of country characteristics and trends that may threaten the system identification. That is, we assume that, once a full array of time-invariant characteristics and trends of a country are controlled for, the remaining variation between that country's and its neighbours' income and democracy should be plausibly distinct to the respective outcome, at least contemporaneously. Notwithstanding this very restrictive approach, one may argue that $(logNY)$ in equation (2) may influence $Polity2$ in equation (3) through other channels, that is, it may not be excluded from equation (3). These mechanisms typically concern time-*variant* factors. The main possibility in this case is trade and other bilateral relationships: a spurt in trade with bordering countries may be associated with a similar spurt in the income and democracy of a country. We empirically test for this possibility by including in equations (2) and (3) the share of trade with neighbours, but our results remain unaffected (unreported). We also control for whether a country is a member of a trading bloc, including the European Union, Commonwealth of Independent States, North American Free Trade Agreement, Association of South East Asian Nations, and Gulf Cooperation Council, and find that such controls make little change to our results (unreported).

An additional check is in line with Acemoglu et al. (2008) who test, using a large panel of world countries analogous to ours, for the relationship between trade-weighted world democracy and democracy at home. We include trade-weighted income and trade-weighted polity in income and polity equations respectively, both in separate and joint models as additional possible exogenous variables, in the presence of log of neighbours' average GDP and neighbours' average polity score, but we find qualitatively similar results (*see* Appendix A5). This indicates that trade-related bilateral effects are unlikely to contaminate our findings.

Using neighbours' conditions as source of exogenous variation may raise doubts from a different perspective: if the performances of bordering countries affect a country's income and polity2, the country could have reciprocal effects on its neighbours for the same reasons. In our dataset, 143 of 160 countries have more than one neighbour. This suggests that on average, a country is less likely to affect its adjacent (multiple) neighbours to the same extent that the neighbouring countries could collectively influence that country.[6]

Despite all these caveats, we may still be unable to entirely rule out the possible endogeneities that may occur through other time-variant political, social and cultural factors associated with neighbours' variables. However, it should be reiterated that our restrictive empirical design and a wide array of robustness checks along with pining down possible mechanisms in the key relationships explored support the view that other channels through which neighbours may affect a country are likely to be minor in our context.

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[6] An alternative concern is that a catastrophic earthquake may produce a huge loss of lives despite government's preventive efforts towards disaster risk mitigation. Under such scenario, the signal of regime incompetence to its citizens tends to be unclear. Rather, it is "excess" fatalities—the death toll beyond what can be expected from the physical intensity of earthquakes—that provide the strongest signal to the population about regime incompetence. Unfortunately we do not have reliable cross-country data on the extent of regime efforts on disaster risk reduction. We, however, estimate our benchmark model by restricting our sample to countries that experience fewer major earthquakes, and find qualitatively similar results compared to the global sample.

5. Results and Discussion

5.1. *Single Equation Results*

Table 2 reports the results for the single equation estimations. All regressions control for country-fixed effects, common time effects, and country-specific time trends. Column (1) finds that the OLS estimate of $logGM$ on *Polity2* is positive but has a t-statistic of only 1.52. Yet, a positive and near-significant coefficient suggests that, on average, earthquakes improve the level of democracy. Column (2) presents the OLS estimate of *Death* on *Polity2*. The estimate is negative and significant at 5%, but it is subject to several biases such as omitted variables and possibly reverse causation. Column (3) reports the instrumental variable version of column (2), where the lower panel presents effect of $logGM$ on *Death* in the first stage, and the upper panel presents the estimate of *Death* on *Polity2* in the second-stage. The model is estimated with IV-LIML, which is robust to weak instruments. The first-stage shows a positive and strongly significant effect of $logGM$ on *Death*, with first-stage F-statistic of about 7. The second-stage finds a positive effect of *Death* on *Polity2* with a t-statistic of 1.61. The change in sign from column (2) to (3) is noteworthy, because it shows that with several biases eliminated, earthquake damages could lead to better democracy. Despite being insignificant at conventional levels, the coefficient on *Death*, 1.52, implies that for every one thousand death due to earthquakes in every one million people in a given year, the polity score in that year increases by 1.52 units in the range of [-10, 10] in this global sample. Next, column (4) adds income as a control. Clearly, income itself may be subject to endogeneity problems in this model, but its inclusion does not make a difference to *Death*. Including income squared in column (5) makes no difference either.

In columns (6) to (10) we estimate the effect of $logGM$ and *Death* on income. Column (6) displays no significant relationship between $logGM$ and income using OLS. Column (7) shows that the OLS estimate of *Death* on income is positive and significant, but again OLS is likely to provide biased estimates here. Column (8) estimates the IV-LIML model, with the second-stage effect of *Death* on $logY$ being insignificant. Finally, columns (9) and (10) estimate the IV-LIML models for low-income and high-income regimes, respectively. *Death* is estimated with negative and positive signs in the respective regime, yet with insignificant coefficients.

Although the single-equation setting provides some evidence for a positive effect of *Death* on *Polity2* with a coefficient of 1.52, this effect is weakly significant and is likely to be reflective of its total effect. The single-equation set-up does not pick up any income effect of *Death*, but it is not clear whether the model can detect the possible feedback mechanisms here. Next, we estimate a system of equations in order to trace the two hypothesized components of the total effect, the affective shock and the income effects, in an integrated framework.

5.2. *System of Equations Results*

Model 3.1 in Table 3 shows that earthquake shocks, measured in terms of ground-motion amplitude and death toll, have two opposite effects on the level of democracy. On the one hand, controlling for country-specific heterogeneity, common time shocks and country-specific long-term trends, earthquakes exert a strong affective shock effect on the level of democracy as shown by the estimate in equation (3) of the system. The estimate indicates that every one thousand death in every one million people in a given year improves the Polity2 score in a country by 1.78 points in that year, an effect that is statistically significant at the 1% level. Earthquake shocks are likely to cause the voters to release their wrath against the incumbent regime because of the human and physical damages incurred.

Our estimates in equations (1) and (2) of the system also show that every one thousand death in every one million increases per capita GDP by 0.374 per cent in that year, which then decreases the Polity2 score by 0.59 point (0.374 × –1.567) in the scale of [–10, 10]. Both effects are statistically significant at 1% level. The positive relationship between earthquake death toll and income in a given year implies that the short-run emergency response and recovery expenditures boost the economy. Meanwhile, the negative relationship between income and *Polity2* score (i.e., –1.567) is consistent with Acemoglu and Robinson (2001) in that increased economic activity due to post-disaster expenditure on reconstruction and rehabilitation is ultimately associated with increased opportunity cost of contesting the incumbent regime.

Considering the affective shock and income effects together, the net effect of earthquakes, therefore, is that every one thousand earthquake-related deaths in every one million in a given year is associated with an improvement of 1.19 points (i.e., 1.78 – 0.59) in the Polity2 score. Taken together, these results suggest that earthquake shocks open a democratic window of opportunity, but this window is narrowed by improved economic conditions.

In Table 3, Model 3.2, we use the total number of affected people instead of death toll in earthquakes. The estimates indicate that, measured this way, earthquake shocks have only an income effect on the level of democracy and, somewhat expectedly, a zero affective shock effect. In particular, every one thousand people in every one million people affected by earthquake is associated with a 0.003 point lower Polity2 score through the income channel. While statistically significant, this effect is numerically low. The statistical insignificance of the affective shock effect suggests that it is the death toll and consequent human and physical damages that trigger the nature of being shocked, rather than being affected, which is ultimately reflected to the incumbent regime. What is common between the effects of death toll and the total affected in earthquakes, though, is that both affect the Polity2 score negatively through raising income.

In Table 4, Model 4.1 uses only the sample of developing countries and Model 4.2 utilizes that for developed countries, both using the death toll measure. In Model 4.1, both the affective shock and income effects of death toll in earthquakes qualitatively remain similar to that in Model 3.1. In particular, the affective shock effect, which is statistically significant at the 5% level, suggests that every one thousand earthquake-related death in every one million people is associated with 2.33 higher democracy score in developing countries. The positive income effect of death toll means that it is developing countries that drives the income boost observed in the full sample (see also below), meaning an average developing country expends significant resources on short-term emergency response and recovery in the wake of earthquakes. However, the increased income raises the cost of contesting the incumbent, narrowing the democratic window of opportunity by 0.97. In sum, the net effect of earthquake death toll in developing countries is a movement into democracy by 1.36 points in the Polity2 scale.

Model 4.2 shows an insignificant affective shock effect of earthquake death toll on democracy in developed countries. This finding, unsurprisingly, suggests that governments in developed countries tend to be more effective at reducing earthquake risks (e.g., in terms of implementing appropriate building codes, earthquake contingency plans, Standing Orders on

Disaster (SoD) and disaster management acts). Consequently, post-earthquake affective shocks and the scope for the incumbent regime being held responsible for failure are minimised. In terms of the income effect of death toll, developed countries exhibit insignificant effect of death toll on income levels and on democracy. Consistent with the argument above, this finding suggests that earthquakes do not cause significant damages in developed countries to begin with. In sum, the results in Model 4.2 indicate that developed countries exhibit neither an affective shock nor an income effect of earthquakes on democracy. It is noteworthy that all the distinct exogenous variables in Table 4 are strongly significant, rendering the system estimates reliable.

5.3. *Robustness Checks*

Our results related to earthquake-driven income changes may differ in different clusters of democracy (*see* Epstein et al. 2006; Przeworski et al. 2000). Moreover, if our interpretation that the direct effect captures voters' affective reaction to earthquakes is correct, then autocratic countries should be less likely to exhibit this reaction, due to the oppressive nature of those regimes. Bearing out this falsification test, Table 5, Model 5.1 reports the affective shock effect to be insignificant in autocratic countries (i.e., countries with a Polity2 score between –10 and 0). However, there is a dramatic affective shock effect in partially democratic countries (with Polity2 scores between 1 and 7) in the order of an increased democracy score of 4.6 due to every one thousand deaths in every one million people. Considering the income channel too, the net total effect is 4.2 points. This finding strongly suggests that, in partially democratic countries, outrage expressed by citizens may lead to political change, and the net outcome is a significant improvement in democracy. In Model 5.3, using fully democratic countries (those with Polity2 scores of 8 to 10), no evidence is found for affective shock or income effects of earthquakes. The lack of a direct effect here suggests that people in fully democratic countries are not prone to punish the incumbent after earthquakes, probably because it has taken all the measures.

The second robustness check of the affective shock effect is related to the intensity of earthquakes. An earthquake with Richter scale magnitude of seven is equivalent to 10 earthquakes with Richter magnitude six in terms of ground tremor. However, *one* earthquake with magnitude seven compared to 10 earthquakes with magnitude six should generate varied reaction among citizens. To check whether repetitive catastrophes fail to surprise citizens such that they wash away sensitivity, we augment our baseline Equations (1) and (3) by including the *number* of earthquakes with Richter scale of 5 and above in a given year. In this case, affective shock effect is estimated to be insignificant, suggesting that frequent earthquakes fail to surprise citizens, whereby the political regime remains more stable. The frequency of earthquakes itself has a positive and significant sign, indicating a democratic improvement (unreported).[7, 8, 9]

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[7] We also check the robustness of the feedback effect in equation (1). Excluding income and its quadratic from equation (1) expectedly changes our results. In this case, the system estimation yields the results that are very similar to the single-equation results in Table 2: a positive and near-significant affective shock effect and insignificant income effect of earthquakes. This suggests that modelling the simultaneity between income and death is crucial to obtain our findings.

[8] Another robustness check is related to the sample composition. Earthquakes are not distributed evenly all over the world, and our results can be driven by a few countries with frequent earthquakes. Following Toya et al. (2010), we conduct robustness checks concerning the 'Ring of Fire' countries, where 90% of the quakes occur globally. In unreported regressions, excluding the Ring of Fire countries from the full sample finds that the affective shock effect is significant and drives a democratic improvement. The income effect is upheld too.

[9] The *Death* variable in equation (3) might capture international disaster aid efforts, whereby a greater amount of aid relief, attracted by a higher death toll, might spuriously affect citizens' perception of the incumbent regime in a positive direction. To rule out such a possibility, we control for disaster aid in equation (3). Though the quality of data on disaster aid in EMDAT is questionable, our results remain unchanged with this exercise (unreported).

6. Possible Mechanisms

We now turn to possible mechanisms through which the affective shock and income effects of earthquakes on democracy may arise.

6.1. *Mechanisms for the Affective Shock Effect of Earthquakes*

We interpret the direct effect of earthquakes as the affective shock experienced by citizens, which may also be fueled by the incumbent regime's poor performance in emergency response. In what follows, we provide evidence for two situations under which the post-earthquake affective shock is rebounded to political sphere: election proximity and the level of insured risk.

Election proximity. Cole, Healy, and Werker (2012) demonstrate that voters punish the incumbent party for weather events beyond its control. However, fewer voters punish the incumbent regime if it takes appropriate measures that address the emergency response and recovery phases effectively (*see* Healy and Malhotra 2009). Using this intuition, we augment our equation (3) with three additional variables where a binary indicator of the national elections in the past year[10] is interacted with three most recent lags of earthquake death tolls. Model 6.2 in Table 6 demonstrates that the direct effect of earthquakes on democracy disappears once we control for these interactions. Importantly, the coefficient of the interaction term involving one year-lagged death toll and elections is estimated to be positive and significant, while the interaction terms involving the prior lags of the earthquake death toll are insignificant. This finding indicates that when national elections and earthquakes both occur within a given year,

[10] Using the National Elections across Democracy and Autocracy (NELDA) dataset, we construct the election year dummy variable if any election—including presidential, legislative, parliamentary, and constituent assembly—takes place in a given year (*see* Hyde and Marinov 2012).

the polity score is increased significantly by 5.3 points in the following year. This outcome can arise in two ways. The first possibility is that the earthquake occurs before the election within the year such that citizens punish the incumbent in the election for its failure. Presumably this punishment paves the way for the election of a more democratic regime. The second possibility is that the earthquake occurs after the elections in that year whereby the newly elected government behaves democratically and its willingness to support the victims is substantial aiming to reduce the citizens' affective shock.

Insured Risk. The affective shock experienced by citizens due to earthquakes may particularly be fueled by the incumbent regime's poor performance in post-disaster response. However, this effect is likely to be weaker or even absent in countries where disaster-related damages are covered by insurance packages. We argue that the level of insurance premium in a country would proxy the extent of insured risks; the higher the premium, the broader the coverage of insured disaster risks, thus the lower the possibility of a regime-changing affective shock.[11] With this hypothesis at disposal, we run our benchmark model (i.e. Model 3.1) by splitting the dataset into two sub-samples— countries below the median of average per capita insurance premium and countries above the median of the same.[12] Table 7 demonstrates that the

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[11] Insurance packages can be both life and non-life. One question is whether insurance premiums can differ across two countries because of their differences in disaster risks. Our within-country variation would capture the increase in insurance premiums within a locality due to better coverage of disaster risks over time. Another question is whether insurance premiums can reflect anomalies in the local insurance market. That insurance premiums reflect a market anomaly (perhaps, a supply-demand disequilibrium) is a possibility, but in most countries, the insurance market is competitive and comprise multinationals that have relatively standard pricing policies across countries..

[12] The world median of average per capita total direct insurance premiums (life and nonlife) is USD 140. Notably, the sample of countries with average insurance premiums greater than the median does not completely overlap with the cohort of developed countries used in Table 4.

affective shock effect of earthquakes on democracy is absent in countries with higher insurance premium, but it is very significant in countries with lower insurance premium.

6.2. *Mechanism for the Income Effect of Earthquakes*

We now investigate how earthquake-related damages may improve the income level. Earthquakes may trigger a multitude of financial activities by boosting expenditure on post-disaster recovery and reconstruction, which would in turn increase income levels. Unfortunately, we do not have consistent data on the amount of disaster-related domestic expenditures for a wide range of countries over time. Instead, we assume that such stimulus is likely to be observed in economies with larger governments, where new expenditures can be generated relatively easily in short-run. Based on this conjecture, models 8.1 and 8.2 of Table 8 show the results for two sub-samples— countries with small and large government sizes, respectively, where the sample split is based on the median value of the share of government expenditures in GDP. The results indicate that earthquake death toll does not affect income in countries with small government size. On the contrary, as depicted in column 5 of Table 8, earthquake damages are associated with higher income in countries with larger government size. We check this hypothesis with 2SLS as well, and find similar findings (*see* Appendix A6).

7. Conclusions

Using the ground-motion amplitude derived from the Richter magnitude scale to explain the earthquake death toll and covering almost all independent countries in the world for the period 1950 to 2007, our analysis indicates that earthquake shocks have two contradicting effects on democratic conditions. First, earthquakes directly drive movements into democracy through a direct effect. We interpret this effect as the reaction of voters to earthquake shocks whereby they bounce their affective shock to the incumbent regime, holding them responsible for earthquake damages, human and physical. Moreover, we find that this effect is driven by partially democratic countries, which have greater room for democratic improvement, and is absent in autocratic and fully democratic countries.

The second effect of earthquakes is reduced democracy through elevated income levels. In this vein, we first show that the effect of earthquakes on income is positive. This effect is contemporaneous, and most possibly driven by short-term emergency response and recovery expenditures, as it is more pronounced in countries with larger governments. Next, we find that increased income is associated with somewhat reduced democracy, probably because it raises the opportunity cost of contesting the incumbent regime, as per the political transitions theory of Acemoglu and Robinson (2001). In sum, the earthquake shocks open a new democratic window of opportunity, but this window is somewhat narrowed by improved economic conditions.

Numerically, the affective shock and income effects together amount to every one thousand death in every one million people in earthquakes improving the Polity2 score democracy by 1.2 points. In the sample of partially democratic countries, the effect is much more dramatic, 4.6 points. While this evidence may not indicate a complete regime transition, it suggests that earthquake shocks have important direct effect on democracy as well as through the income channel in a significant set of countries. Further, the paper documents some mechanisms for the direct and indirect effects through which the said effects may arise, namely, the election proximity and the extent of insured-risk mechanisms for the affective shock channel, and the government stimulus mechanism for the income channel. While we cannot claim that our results are fully causal, they are robust to restrictive specifications, and several sensitivity and falsification tests, which take into account the differential political regimes, different samples and earthquake intensities. However, modelling the simultaneity between earthquake fatalities and the level of income in a structural framework is a crucial factor behind our findings.

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Figures and Tables

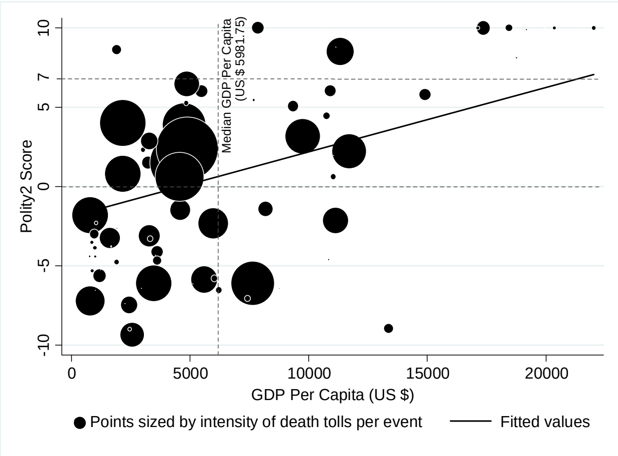

Figure 1: *The Link Between Earthquake Death Toll, GDP per Capita and Polity2 Score*

Note. The size of each dot is proportional to the intensity of death toll. Countries with Polity2 score below 0 are autocratic; between 0 to 7 partial democratic; and above 7 fully democratic countries. Observations are averaged by country from 1950 to 2009; each of 162 dots represents a country.

Table 1

Descriptive Statistics

Variable	**Mean**	**Std. Dev.**	**Observations**
Log Ground Motion in Earthquakes (in Millimeters), t	0.3168	1.5997	11303
Death Toll in Thousand Population, *t*	0.0058	0.1628	10951
Total Affected in Thousand Population, t	0.7413	20.4938	10951
Log Real GDP per capita, t	8.4621	1.1288	8368
Log Neighbours' Average GDP, t	25.6536	1.7695	8476
Polity2, *t*	0.0726	7.5125	7608
Neighbours' Average Polity2, t	0.9289	6.7809	8266

Table 2

Earthquake Death Toll, Income, and Democracy: Single-Equation Results

Model	**Polity2, *t***	**Polity2, *t***	**Polity2, *t***	**Polity2, *t***	**Polity2, *t***	**Polity2, *t***	**Polity2, *t***	**Log Real GDP per capita, *t***	**Log Real GDP per capita, *t***	**Log Real GDP per capita, *t***	**Log Real GDP per capita, *t***	**Log Real GDP per capita, *t***
	LS	LS	LS	LS	IV-LIML	IV-LIML	IV-LIML	LS	LS	IV-LIML	IV-LIML	IV-LIML
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Panel A:												
Log Ground Movement in	0.035	0.034	0.034					-0.001				
Earthquakes (in mm), t	(0.023)	(0.022)	(0.022)					(0.001)				
Death Toll per				-0.360	1.517	1.500	1.484		0.011	-0.026	-0.089	0.035
Thousand Population, t				(0.163)**	(0.949)	(0.940)	(0.943)		(0.002)***	(0.053)	(0.093)	(0.048)
Log Real GDP		-0.610	-4.635			-0.649	-4.620					
Per Capita, t		(0.735)	(3.822)			(0.738)	(3.837)					
Log Real GDP			0.243				0.240					
Per Capita Squared, t			(0.221)				(0.222)					
Panel B:					***First Stage for Death Toll per Thousand Population, t***							
Log Ground Movement in					0.023	0.023	0.023			0.023	0.017	0.027
Earthquakes (in mm), t					(0.009)***	(0.009)***	(0.009)***			(0.009)***	(0.011)	(0.012)**
Log Real GDP						0.026	-0.010					
Per Capita, t						(0.016)*	(0.042)					
Log Real GDP							0.002					
Per Capita Squared, t							(0.003)					
Kleiberg-Paap F-Statistic					7.09	7.08	7.08			7.09	2.43	4.63
Sample	Full	Full	Full	Full	Full	Full	Full	Full	Full	Full	Low-Income	High-Income
Observations	6,257	6,257	6,257	6,257	6,257	6,257	6,257	6,257	6,257	6,257	3,273	2,984

Notes. Huber robust standard errors (in parentheses) that are clustered at the country level. LIML: Fuller limited information maximum likelihood. All equations include country fixed effects, country time trend, and common time effects. The polity measure of democracy (Polity2) is discrete that ranges between [−10, 10], where the greater value represents the higher level of democracy, and the vice versa. Low-income and high-income sample of countries in columns 11 and 12, respectively, correspond to countries with real GDP per capita lower and higher than 50th percentile (USD 4768.55) in the full sample, respectively. *Significant at 10% level; **significant at 5% level; ***significant at 1% level.

Table 3

Earthquake Death Toll, Income, and Democracy: System of Simultaneous Equations

Model	**3.1: Effects of Death Toll**			**3.2: Effects of Affected Population**		
	Death Toll per Thousand Population, *t*	**Log Real GDP per capita,** ***t***	**Polity2,** ***t***	**Total Affected per Thousand Population,** *t*	**Log Real GDP per capita,** ***t***	**Polity2,** ***t***
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Log Ground Motion in Earthquakes (in mm), t	0.018 (0.002)***			2.588 (0.208)***		
Log Real GDP per Capita, t	2.951 (1.693)*		–1.567 (0.263)***	319.1 (218.8)		–1.272 (0.262)***
Squared Log Real GDP per Capita, t	–0.136 (0.100)			–14.67 (12.93)		
Death Toll per Thousand Population , t		0.374 (0.055)***	1.782 (0.996)*			
Total Affected per Thousand Population , t					0.002 (0.0004)***	0.012 (0.008)
Log Neighbours' Average GDP, t		–0.023 (0.012)*			–0.022 (0.012)*	
Neighbours' Average Polity2, t			0.130 (0.016)***			0.130 (0.016)***
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Country Time Trend	Yes	Yes	Yes	Yes	Yes	Yes
Common Time Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,257	6,257	6,257	6,257	6,257	6,257

Notes. Three-stage least squares estimation. In parentheses are the robust standard errors clustered at the country level. *Significant at 10% level; **significant at 5% level; ***significant at 1% level.

Table 4

Earthquake Death Toll, Income, and Democracy:

Developing Versus Developed Countries

Model	**4.1: Developing Countries**			**4.2: Developed Countries**		
	Death Toll per Thousand Population, t	**Log Real GDP per capita, *t***	**Polity2, *t***	**Death Toll per Thousand Population, t**	**Log Real GDP per capita, *t***	**Polity2, *t***
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Log Ground Motion in Earthquakes (in mm), t	0.02 (0.002)***			0.0008 (0.0001)***		
Log Real GDP Per Capita, t	–1.078 (2.790)		–2.624 (0.345)***	0.043 (0.084)		0.233 (0.289)
Squared Log Real GDP Per Capita, t	0.117 (0.175)			–0.002 (0.005)		
Death Toll per Thousand Population , t		0.369 (0.050)***	2.325 (0.983)**		0.729 (3.422)	25.521 (41.024)
Log Neighbours' Average GDP, t		0.025 (0.016)			–0.068 (0.017)***	
Neighbours' Average Polity2, t			0.043 (0.019)**			0.260 (0.026)***
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Country Time Trend	Yes	Yes	Yes	Yes	Yes	Yes
Common Time Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,537	4,537	4,537	1,720	1,720	1,720

Notes. Three-stage least squares estimation. In parentheses are the robust standard errors clustered at the country level. Estimations by substituting 'Total affected per thousand population' for 'Death toll per thousand population' provide qualitatively similar results. *Significant at 10% level; **significant at 5% level; ***significant at 1% level.

Table 5

The Effect of Earthquake Death Toll on Democracy:

Different Sub-Samples Based on Polity Scores

Model	**5.1: Polity from –10 to 0**			**5.2: Polity from 1 to 7**			**5.3: Polity from 8 to 10**		
	Death Toll per Thousand Population, *t*	**Log Real GDP per Capita,** ***t***	**Polity2,** ***t***	**Death Toll per Thousand Population,** *t*	**Log Real GDP per Capita,** ***t***	**Polity2,** ***t***	**Death Toll per Thousand Population,** *t*	**Log Real GDP per Capita,** ***t***	**Polity2,** ***t***
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
Log Ground Motion	0.052			0.014			0.002		
in Earthquakes (in mm), t	(0.004)***			(0.002)***			(0.0003)***		
Log Real GDP	1.404		–1.217	–0.767		–1.824	–0.012		0.518
Per Capita, t	(2.089)		(0.231)***	(3.243)		(0.835)**	(0.978)		(0.318)
Squared Log Real GDP	–0.063			0.086			–0.004		
Per Capita, t	(0.121)			(0.204)			–0.053		
Death Toll per		0.079	0.606		0.268	4.646		–0.840	5.386
Thousand Population , t		(0.039)**	(0.475)		(0.088)***	(2.253)**		(0.378)**	(5.321)
Log Neighbours'		–0.055			0.160			–0.033	
Average GDP, t		(0.022)**			(0.025)***			(0.009)***	
Neighbours'			0.082			–0.047			–0.0004
Average Polity2, t			(0.0170)***			(0.032)			(0.012)
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Time Trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Common Time Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,906	2,906	2,906	1,107	1,107	1,107	2,104	2,104	2,104

Notes. Three-stage least squares estimation. In parentheses are the robust standard errors clustered at the country level. *Significant at 10% level; **significant at 5% level; ***significant at 1% level.

Table 6

The Affective Shock Effect of Earthquakes: Election Proximity Mechanism

Model	**Model 6.1**			**Model 6.2**		
	Death Toll in Thousand Population, t	**Log Real GDP per capita, t**	**polity2, t**	**Death Toll in Thousand Population, t**	**Log Real GDP per capita, t**	**polity2, t**
	(1)	(2)	(3)	(4)	(5)	(6)
Log Ground Movement in Earthquakes (in millimeters), t	0.0187			0.019		
	(0.002)***			(0.002)***		
Log Real GDP per capita, t	3.013		-1.613	3.497		-1.394
	(1.734)*		(0.269)***	(1.697)**		(0.268)***
Squared Log Real GDP Per Capita, t	-0.140			-0.169		
	(0.102)			(0.100)*		
Log Neighbours' Average GDP, t		-0.027			-0.029	
		(0.012)**			(0.01)**	
Neighbours' Average Polity2, t			0.141			0.139
			(0.016)***			(0.016)***
Death Toll in Thousand Population, t		0.346	1.853		0.345	1.570
		(0.054)***	(0.982)*		(0.050)***	(0.980)
Death Toll in Thousand Population, t-1						-0.336
						(0.177)*
Death Toll in Thousand Population, t-2						-0.373
						(0.180)**
Death Toll in Thousand Population, t-3						-0.324
						(0.252)
Election year dummy, t-1						0.635
						(0.105)***
Death Toll in Thousand Population, t-1 * Election year dummy, t-1						5.303
						(3.060)*
Death Toll in Thousand Population, t-2 * Election year dummy, t-1						0.220
						(0.817)
Death Toll in Thousand Population, t-3 * Election year dummy, t-1						-0.195
						(0.347)
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Country Time Trend	Yes	Yes	Yes	Yes	Yes	Yes
Common Time Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5,922	5,922	5,922	5,922	5,922	5,922

Notes. Three-stage least squares estimation. In parentheses are the robust standard errors clustered at the country level. We construct Election year dummy by assigning 1 if any form of national elections—including presidential, legislative, parliamentary, and constituent assembly— takes place in a given year, 0 otherwise (Hyde and Marinov 2012).*Significant at 10% level; **significant at 5% level; ***significant at 1% level.

Table 7

The Affective Shock Effect of Earthquakes: Insured Risk Mechanism

Model	**Model 7.1: Sample with Countries Above the Median Insurance Premium**			**Model 7.2: Sample with Countries Below the Median Insurance Premium**		
	Death Toll in Thousand Population, t	**Log Real GDP per capita, t**	**Polity2, t**	**Death Toll in Thousand Population, t**	**Log Real GDP per capita, t**	**Polity2, t**
	(1)	(2)	(3)	(4)	(5)	(6)
Log Ground Movement in Earthquakes (in millimeters), t	0.007 (0.001)***			0.014 (0.003)***		
Log Real GDP per capita, t	0.957 (0.691)		1.556 (0.434)***	4.644 (4.463)		-6.069 (0.638)***
Squared Log Real GDP Per Capita, t	-0.044 (0.035)			-0.199 (0.259)		
Death Toll in Thousand Population, t		0.865 (0.245)***	4.039 (4.502)		0.394 (0.062)***	3.784 (1.350)***
Log Neighbours' Average GDP, t		-0.078 (0.013)***			0.077 (0.024)***	
Neighbours' Average Polity2, t			0.201 (0.025)***			-0.019 (0.031)
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Country Time Trend	Yes	Yes	Yes	Yes	Yes	Yes
Common Time Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,801	1,801	1,801	2,007	2,007	2,007

Notes. Three-stage least squares estimation. In parentheses are the robust standard errors clustered at the country level. The data on insurance premiums are sourced from Swiss Re (2010), Sigma (*See* Appendix A1). The median of average per capita total direct insurance premiums (life and nonlife) in USD is 140. Notably, the sample of countries with average insurance premiums greater than the median does not completely match with the cohort of developed countries used in Table 4. For instance, there are 61 developed countries of which 19 are with average insurance premiums less than its median. *Significant at 10% level; **significant at 5% level; ***significant at 1% level.

Table 8

The Income Effect of Earthquakes: Government Size

Model	**8.1: Sample with Countries Below the Median Government Size**			**8.2: Sample with Countries Above the Median Government Size**		
	Death Toll in Thousand Population, t	**Log Real GDP per capita, t**	**polity 2, t**	**Death Toll in Thousand Population, t**	**Log Real GDP per capita, t**	**polity 2, t**
	(1)	(2)	(3)	(4)	(5)	(6)
Log Ground Movement in Earthquakes (in mm), t	0.030 (0.003)***			0.010 (0.001)***		
Log Real GDP per capita, t	6.537 (4.526)		-1.325 (0.381)***	-0.416 (1.61)		-1.643 (0.464)***
Squared Log Real GDP per Capita, t	-0.357 (0.261)			0.045 (0.100)		
Death Toll in Thousand Population, t		0.048 (0.043)	0.468 (0.936)		0.631 (0.125)***	3.427 (2.828)
Log Neighbours' Average GDP, t		-0.034 (0.014)**			0.029 (0.014)**	
Neighbours' Average Polity2, t			0.171 (0.022)***			0.095 (0.022)***
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Country Time Trend	Yes	Yes	Yes	Yes	Yes	Yes
Common Time Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,326	3,326	3,326	2,933	2,933	2,933

Notes. Three-stage least squares estimation. In parentheses are the robust standard errors clustered at the country level. The median share of government expenditures in GDP in our dataset is 15.88 per cent. Notably, the sample of countries with more than the median of government share does not completely match with the cohort of developed countries used in Table 3. *Significant at 10% level; **significant at 5% level; ***significant at 1% level.

Appendix A1: Data and Sources

Variable	Description	Source
$Death$	Death toll per thousand people in earthquakes: the total number of deaths due to all earthquakes occurred in a given year in each country	EM-DAT dataset available at http://www.emdat.be/
$Affected$	Total affected per thousand people in earthquakes: the sum of total injured, homeless and affected people due to all earthquakes occurred in a given year in each country	EM-DAT dataset
GM	Ground motion in earthquakes (in millimetres): constructed using Richter scale measure of earthquake events from 1950 to 2007	Calculated from earthquake Richter scale data at http://www.emdat.be/
$EQfrequency$	Number of 5+ earthquakes in Richter scale in a given year for each country	http://www.emdat.be/
Insurance	Average per capita total direct insurance premium (life and nonlife) in USD	Sigma database (Swiss Re 2010)
y	Real GDP per capita (Constant Prices: Chain series)	http://pwt.econ.upenn.edu/
NY	Average GDP of neighbouring countries: constructed using real GDP per capita dataset from PWT	Calculated from Penn World Tables (PWT)
Govtsize	Government Share of PPP Converted GDP Per Capita at 2005 constant prices (%)	http://pwt.econ.upenn.edu/
$Polity2$	Polity measure of democracy: the range of this measure is from –10 to 10; positive (negative) values indicate an improvement (deterioration) in democracy	Marshall and Jaggers (2005)
NP	Average Polity2 score of neighboring countries: constructed using Polity measure of democracy	Calculated from Polity IV database
Election Year	Dummy variable if any election—including presidential, legislative, parliamentary, and constituent assembly—takes place in a given year. Legislative/Parliamentary, Executive, Constituent Assembly	National Elections Across Democracy and Autocracy (NELDA) Dataset (Hyde and Marinov 2012)

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Appendix A2: Countries Included in the Sample

Country	Code	Country	Code	Country	Code
Afghanistan	AFG	Cyprus	CYP	Italy	ITA
Albania	ALB	Czech Rep	CZE	Ivory Coast	IVO
Algeria	DZA	Denmark	DNK	Jamaica	JAM
Angola	AGO	Djibouti	DJI	Japan	JPN
Argentina	ARG	Dominican Rep	DOM	Jordan	JOR
Armenia	ARM	Ecuador	ECU	Kazakhstan	KAZ
Australia	AUS	Egypt	EGY	Kenya	KEN
Austria	AUT	El Salvador	SLV	Korea Rep	KOR
Azerbaijan	AZE	Equatorial Guinea	GNQ	Kuwait	KWT
Bahrain	BHR	Eritrea	ERI	Kyrgyzstan	KGZ
Bangladesh	BGD	Estonia	EST	Lao P Dem Rep	LAO
Belarus	BLR	Ethiopia	ETH	Latvia	LVA
Belgium	BEL	Fiji	FJI	Lebanon	LBN
Benin	BEN	Finland	FIN	Lesotho	LSO
Bhutan	BTN	France	FRA	Liberia	LBR
Bolivia	BOL	Gabon	GAB	Libyan Arab Jamah	LBY
Bosnia-Herzegovinian	BIH	Gambia The	GMB	Lithuania	LTU
Botswana	BWA	Georgia	GEO	Macedonia FRY	MKD
Brazil	BRA	Germany	GER	Madagascar	MDG
Bulgaria	BGR	Germany Fed Rep	DFR	Malawi	MWI
Burkina Faso	BFA	Ghana	GHA	Malaysia	MYS
Burundi	BDI	Greece	GRC	Mali	MLI
Cambodia	KHM	Guatemala	GTM	Mauritania	MRT
Cameroon	CMR	Guinea	GIN	Mauritius	MUS
Canada	CAN	Guinea Bissau	GNB	Mexico	MEX
Central African Rep	CAF	Guyana	GUY	Moldova Rep	MDA
Chad	TCD	Haiti	HTI	Mongolia	MNG
Chile	CHL	Honduras	HND	Montenegro	MNE
China P Rep	CHN	Hungary	HUN	Morocco	MAR
Colombia	COL	India	IND	Mozambique	MOZ
Comoros	COM	Indonesia	IDN	Namibia	NAM
Congo	COG	Iran Islam Rep	IRN	Nepal	NPL
Costa Rica	CRI	Iraq	IRQ	Netherlands	NLD
Croatia	HRV	Ireland	IRL	New Zealand	NZL
Cuba	CUB	Israel	ISR	Nicaragua	NIC

Niger	NER	Singapore	SGP	Tunisia	TUN
Nigeria	NGA	Slovakia	SVK	Turkey	TUR
Norway	NOR	Slovenia	SVN	Turkmenistan	TKM
Oman	OMN	Solomon Is	SLB	Uganda	UGA
Pakistan	PAK	Somalia	SOM	Ukraine	UKR
Panama	PAN	South Africa	ZAF	United Arab Emirates	ARE
Papua New Guinea	PNG	Spain	ESP	United Kingdom	GBR
Paraguay	PRY	Sri Lanka	LKA	United States	USA
Peru	PER	Sudan	SDN	Uruguay	URY
Philippines	PHL	Swaziland	SWZ	Uzbekistan	UZB
Poland	POL	Sweden	SWE	Venezuela	VEN
Portugal	PRT	Switzerland	CHE	Viet Nam	VNM
Qatar	QAT	Syrian Arab Rep	SYR	Yemen	YEM
Romania	ROM	Taiwan (China)	TWN	Yemen Arab Rep	YMN
Russia	RUS	Tajikistan	TJK	Zaire/Congo Dem Rep	COD
Rwanda	RWA	Tanzania United Rep	TZA	Zambia	ZMB
Saudi Arabia	SAU	Thailand	THA	Zimbabwe	ZWE
Senegal	SEN	Togo	TGO		
Sierra Leone	SLE	Trinidad and Tobago	TTO		

Appendix A3: Is the Income Effect of Earthquakes Contemporaneous or Persistent?

Model	A3.1: Effects of Death Toll			A3.2: Effects of Affected Population		
	Death Toll per Thousand Population, *t*	**Log Real GDP per capita, *t***	**Polity2, *t***	**Total Affected per Thousand Population, *t***	**Log Real GDP per capita, *t***	**Polity2, *t***
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Log Ground Motion in Earthquakes (in mm), t	0.017 (0.002)***			2.603 (0.212)***		
Log Real GDP per Capita, t	3.527 (1.658)**		-2.256 (0.267)***	345.5 (214.5)		-1.737 (0.266)***
Squared Log Real GDP per Capita, t	-0.169 (0.098)*			-16.06 (12.67)		
Death Toll per Thousand Population , t		0.400 (0.055)***	3.108 (0.956)***			
Death Toll per Thousand Population , t-1		0.014 (0.009)				
Death Toll per Thousand Population , t-2		0.013 (0.009)				
Death Toll per Thousand Population , t-3		0.013 (0.009)				
Total Affected per Thousand Population , t					0.002 (0.0004)***	0.020 (0.007)***
Total Affected per Thousand Population , t-1					0.0001 (0.0001)	
Total Affected per Thousand Population , t-2					0.0001 (0.0001)	
Total Affected per Thousand Population , t-3					0.0001 (0.0001)	
Log Neighbours' Average GDP, t		-0.028 (0.013)**			-0.025 (0.012)**	
Neighbours' Average Polity2, t			0.144 (0.016)***			0.144 (0.016)***
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Country Time Trend	Yes	Yes	Yes	Yes	Yes	Yes
Common Time Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,131	6,131	6,131	6,131	6,131	6,131

Notes. Three-stage least squares estimation. In parentheses are the robust standard errors clustered at the country level. *Significant at 10% level; **significant at 5% level; ***significant at 1% level.

Appendix A4: Checking the Exclusion Restrictions of Earthquake Death Toll in Equation (1) of the System of Simultaneous Equations to Physical Capital Investment

Model	**Investment Share of Real GDP per capita (%)**	**Investment Share of Real GDP per capita (%)**	**Investment Share of Real GDP per capita (%)**
	(1)	(2)	(3)
Panel A:			
Log Ground Movement in Earthquakes (in millimeters), t	0.012 (0.038)		
Death Toll in Thousand Population, t		0.506 (1.701)	0.635 (1.667)
Log Real GDP per capita, t			7.328 (10.26)
Squared Log Real GDP per capita, t			-0.172 (0.602)
Panel B: First Stage for Death Toll per Thousand Population, t			
Log Ground Movement in Earthquakes (in mm), t		0.023 (0.009)***	0.023 (0.009)***
Log Real GDP per capita, t			-0.01 (0.042)
Squared Log Real GDP Per Capita, t			0.002 (0.003)
F-statistic		7.09	7.08
Observations	6,257	6,257	6,257

Notes. The robust standard errors clustered at the country level are in parentheses. All equations include country fixed effects, country time trend, and common time effects. First-stage regressions in Panel B are estimated with OLS. In Panel A, Columns 2 and 3 are estimated with 2SLS. *Significant at 10% level; **significant at 5% level; ***significant at 1% level.

Appendix A5: Checking the Exclusion Restrictions of Neighbor-Weighted Income and Democracy Using Trade-Weighted Income and Democracy

Model	A5.1: Direct Effects of Neighbours' Polity2 on per capita GDP			A5.2: Direct Effects of Neighbours' GDP on Polity2			A5.3: Direct Effects of Neighbours' Polity2 on per capita GDP *plus* Direct Effects of Neighbours' GDP on Polity2		
	Death Toll per Thousand Population, t	**Log Real GDP per capita, *t***	**Polity2, *t***	**Death Toll per Thousand Population, t**	**Log Real GDP per capita, *t***	**Polity2, *t***	**Death Toll per Thousand Population, t**	**Log Real GDP per capita, *t***	**Polity2, *t***
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
Log Ground Motion	0.020			0.020			0.020		
in Earthquakes (in mm), t	(0.002)***			(0.002)***			(0.002)***		
Log Real GDP	2.573		-1.995	2.180		-1.964	1.175		-2.049
Per Capita, t	(1.432)*		(0.282)***	(1.505)		(0.283)***	(1.320)		(0.282)***
Squared Log Real GDP	-0.115			-0.091			-0.066		
Per Capita, t	(0.084)			(0.089)			(0.076)		
Death Toll per		0.330	2.457		0.330	2.469		0.330	2.559
Thousand Population , t		(0.054)***	(1.000)**		(0.054)***	(1.005)**		(0.054)***	(1.002)**
Log Neighbours'		-0.030			-0.029	0.022		-0.028	
Average GDP, t		(0.013)**			(0.012)**	(0.240)		(0.012)**	
Neighbours'		-0.000	0.135			0.142			0.135
Average Polity2, t		(0.001)	(0.017)***			(0.017)***			(0.017)***
Trade-weighted			-2.650						-2.664
Polity2 Score, t-1			(0.540)***						(0.540)***
Trade-weighted					-0.007			-0.007	
Log GDP, t-1					(0.009)			(0.009)	
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Time Trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Common Time Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5,476	5,476	5,476	5,476	5,476	5,476	5,476	5,476	5,476

Notes. Three-stage least squares estimation. In parentheses are the robust standard errors clustered at the country level. *Significant at 10% level; **significant at 5% level; ***significant at 1% level.

Appendix A6: The Income Effect of Earthquakes: Government Size in 2SLS Estimation

Model	A7.1: Full Sample	A7.2: Countries Below the Median Government Share of GDP Per Capita	A7.3: Countries Above the Median Government Share of GDP Per Capita
	(1)	(2)	(3)
Panel A: Dependent Variable is Log of Real GDP Per Capita, t			
Death Toll in Thousand Population, t	0.360	-0.211	0.249
	(0.164)**	(0.168)	(0.123)**
Panel B: First stage for Death Toll in Thousand Population, t			
Log Ground Movement in Earthquakes (in mm), t	0.023	0.028	0.020
	(0.009)***	(0.020)	(0.009)**
Log Real GDP per capita, t	-0.010	-0.005	0.101
	(0.043)	(0.037)	(0.120)
Squared Log Real GDP Per Capita, t	0.002	-0.0002	-0.004
	(0.003)	(0.002)	(0.006)
Observations	6,257	2,547	3,714

Notes. The median Government Share of Real GDP per capita in our dataset is 15.88 per cent. In parentheses are the robust standard errors clustered at the country level. All equations include country fixed effects, country time trend, and common time effects. First-stage regressions in Panel B are estimated with OLS. In Panel A, Columns (1–3) are estimated with 2SLS. The coefficient of Log ground movement in earthquakes in Column 2 is significant at 11% level. *Significant at 10% level; **significant at 5% level; ***significant at 1% level.