COMMENT

Port-au-Prince, Haiti, 2010.

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Corruption kills

On the anniversary of Haiti's devastating quake, **Nicholas Ambraseys** and **Roger Bilham** calculate that 83% of all deaths from building collapse in earthquakes over the past 30 years occurred in countries that are anomalously corrupt.

The six-digit death toll from last year's Haiti earthquake compared with the absence of any fatalities in New Zealand's identical magnitude (7) earthquake was a stark reminder that poor building practices are largely to blame for turning moderate earthquakes into major disasters. Earthquake-resistant construction depends on responsible governance, but its implementation can be undermined by corruption[1–5] or by poverty, through the use of substandard materials and assembly methods, or through the inappropriate siting of buildings[6,7].

The effects of these forces are difficult to tease apart, because the poorest nations are often also the most corrupt. To try to isolate these influences, we quantified a global relationship between national corruption[8] and a nation's per capita income[9]. It showed that some nations are more corrupt than anticipated. It is in these countries that about 83% of all deaths from earthquakes in the past three decades have occurred.

The construction industry — currently worth US$7.5 trillion annually and expected to more than double in the next decade — is recognized as being the most corrupt segment of the global economy[10]. Corruption takes the form of bribes to subvert inspection and licensing processes, and of covert activities that reduce costs and thereby compromise the quality of structures. The assembly of a building, from the pouring of foundations to the final coat of paint, is a process of concealment, a circumstance ideally suited to the omission or dilution of expensive but essential structural components. Reports of the spontaneous collapse of new buildings testify to a lack of construction oversight (for example, Shanghai, 27 June 2009; Delhi, 15 November 2010). During earthquakes, the consequences of decades of shoddy construction are revealed on a catastrophic scale[1,2,4,11].

The analysis we present here is a sequel ▶

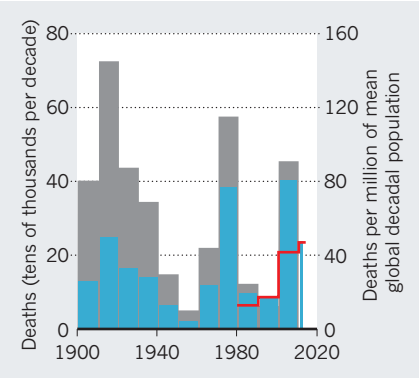

Figure 1 | Earthquake deaths. Despite advances in earthquake engineering, the number of people killed by earthquakes each decade has surged (blue), and the number of deaths as a proportion of global population has not dropped much (dark grey). Many of these deaths can be attributed to building collapse (red).

to a report on the mitigation of earthquake losses that one of us (N.A.) wrote in 1976 for the United Nations Educational, Scientific and Cultural Organization. The section of that report discussing the causes and effects of a lack of transparency on engineering failures was never published[5]. Following more recent earthquakes in China, Pakistan and Haiti, we felt it was imperative to update and air that discussion.

GROUND RULES

The number of deaths continues to climb despite advances in earthquake-resistant design in the past century (Fig. 1). Averaged over the past decade, the fatality rate is 60,000 a year. This average is dominated by the earthquakes in Indonesia in 2004, Kashmir in 2005, Iran in 2005, China in 2008 and Haiti in 2010. It includes fatalities from building collapse and from secondary causes such as tsunami, landslides and fire. Since 1980, fatalities from dwelling collapses, for which an absence of earthquake engineering may be held responsible, average 18,300 a year.

The recent increase in earthquake fatality rates might be supposed to arise from population growth, urbanization or industrial development. Indeed, when adjusted for population growth, deaths from earthquakes are loosely linked with average global populations (Fig. 1). So has the application of earthquake-resistant design and construction of dwellings had any effect in reducing fatalities from earthquakes? Yes: significant nation-to-nation variations in the cumulative death toll indicate that the application of resistant engineering clearly benefits earthquake-prone countries that have the wealth and willpower to mandate its use.

Corruption is by nature covert and difficult to quantify. Yet business people or foreign visitors are frequently willing to disclose its presence on the condition of anonymity. The degree to which corruption is perceived to exist in different countries has been ranked annually[8] since 1995 by Transparency International, a global civil society organization headquartered in Berlin, using a Corruption Perceptions Index (CPI). The score is determined from an aggregate of 13 polls averaged over 2 years from 10 institutions alert to the frequency and extent of bribes paid within various countries. A CPI score of 0 indicates a highly corrupt nation with zero transparency; a score of 10 indicates an absence of perceived corruption with total transparency. The CPI is less reliable for countries with fewer sources of information[12]. We used an average CPI derived from our investigation of long-term fluctuations (Supplementary Fig. 1 — Fig. S1), and its standard deviation (Fig. S2).

Relative wealth is the most obvious parameter that influences a country's corruption. Wealth is frequently attended by a stable constitution conducive to the rule of law. A standard measure that allows comparison of wealth between countries or across economies is the gross national income (GNI) per capita. We chose the World Bank's GNI Atlas method[9] with data averaged over the period 1960 to 2009 (Figs S3 and S4). A clear correlation exists between a nation's per capita income and the level of corruption (Fig. 2). The most corrupt nations are the poorest (Figs S5 and S6).

For earthquakes of the twentieth century, particularly the first half, it is not always possible to confirm published fatality estimates or to calculate new reliable ones. Previous catalogues characterize uncertainties in fatality counts by listing estimates from multiple sources uncritically[13]. The weighting of the most reasonable number from these is largely subjective[4].

We devised a new catalogue by examining original sources such as government reports and aid-agency responses. That said, even for the 2010 Haiti earthquake, reported fatality estimates vary by a factor of three from fewer than 85,000 (an investigative count — probably accurate) to 300,000 (an unsubstantiated guess) (Table S1). Our catalogue distinguishes deaths caused by the collapse of dwellings due to ground shaking from the total number of earthquake-associated deaths, which include those from secondary effects[14] such as aftershocks, landslides, fire and tsunami.

The number of deaths attributable to the collapse of dwellings is influenced by population density and the vulnerability of building stock in the epicentral region. In the past 30 years, the rapid increase in urban populations, particularly in developing countries, has adversely influenced building quality. The number of fatalities depends on whether an earthquake happens at night or during the day, in the winter or in the summer, in a mountainous region or in a valley, after strong and protracted foreshocks and with or without warning[15]. An earthquake occurring on a winter night is likely to kill two to five times more people than one on a summer morning, particularly in a rural region.

GEOLOGY'S ACCOMPLICES

We compared earthquake fatalities from 1980 to 2010 with measures of corruption and wealth. We found, as expected, a direct relationship between poverty and deaths

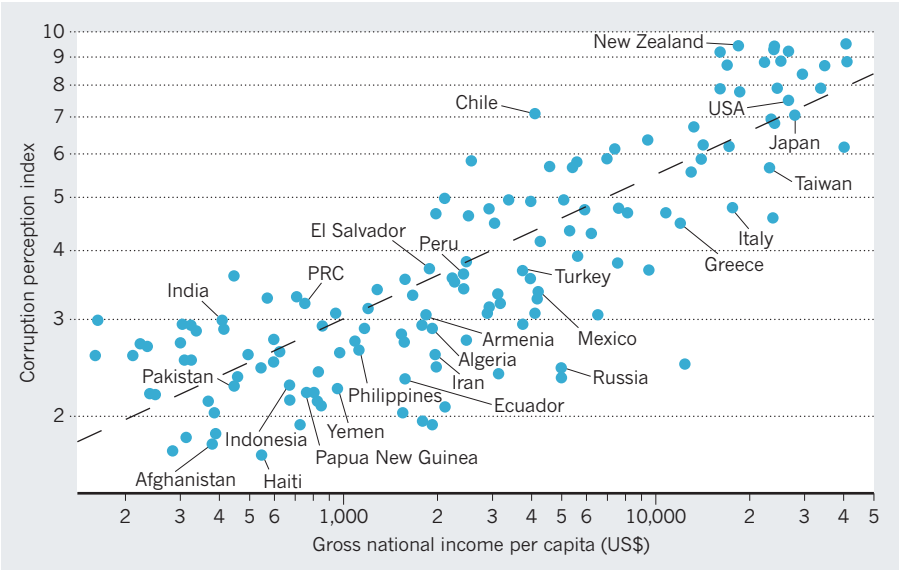

Figure 2 | Cash and corruption. The poorest countries are the most corrupt, but some are more corrupt than others. A weighted regression line (dashed) divides nations that are perceived as more corrupt (below the line) than might be expected from the average income per capita from those that are less corrupt (above the line). Named countries have lost citizens in building collapse caused by earthquakes since 1980.

from earthquakes. Clearly, poverty can lead to the use of unsatisfactory building materials (such as adobe or poor-quality concrete), and to a paucity of education, resulting in ignorance in construction. We also found that corrupt societies have the largest death tolls from earthquakes. For the period 1995 to 2010, when corruption values can be compared directly with earthquake fatalities, we find a quantitative link between the two (Figs S10 and S11). Because the corruption index changed only slowly in this interval (Fig. S1), we assume that CPI values for 1980–95 are similar to post-1995 data (Fig. S2). This assumption is important, because deaths caused by building collapse depend on the corruption prevailing at the time of construction, not at the time of collapse.

Some countries are less corrupt than others with equivalent income levels (Fig. 2). We assigned these outliers an 'expectation index', between −2 and +3 CPI units, with negative values denoting those more corrupt than might be expected. A three-dimensional plot (Fig. 3) reveals that about 83% of all deaths from earthquakes in the past three decades have occurred in poor countries that are more corrupt than one might expect from their per capita income.

This striking correlation does not uniquely distinguish between the relative contributions of poverty and corruption, but it suggests that where corruption is extreme, its effects are manifest in the building industry. The wealthiest of nations afflicted by earthquakes can afford both to educate their populations and to purchase good-quality building materials. So it seems probable that large numbers of fatalities from earthquakes in countries below the regression line in Fig. 2 can be attributed largely to the effects of corruption. By contrast, Chile and New Zealand are less corrupt than might be expected from their per capita income, and have low earthquake fatalities. Japan, with its high per capita income and low levels of corruption, is an anomaly that we attribute to the collapse of older structures in Kobe that predate the adoption of a code of earthquake-resistant building.

"The global construction industry is the most corrupt segment of the world economy."

STARK REMINDER

In sum, there is statistical support for widespread anecdotal evidence of a correlation between corruption and loss of life in earthquakes. Haiti and Iran are extreme examples of nations where fatalities from earthquakes are excessive and where perceived levels of corruption are above average.

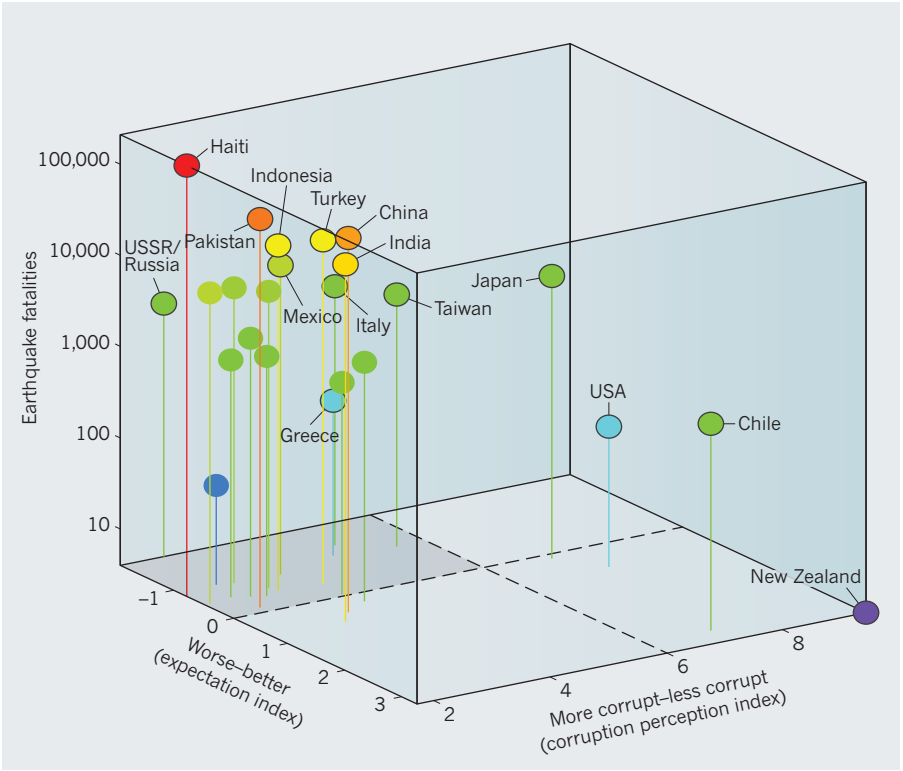

Figure 3 | Corruption's toll. Corruption versus the level of corruption that might be expected from per capita income. Of all earthquake fatalities attributable to building collapse in the past three decades, 82.6% occur in societies that are anomalously corrupt (left-hand corner of the plot).

The statistics also support last year's widely voiced opinions that the probability of earthquake-related deaths is less a function of geography and more the ability to afford earthquake-resistant construction and to enforce building codes.

Sadly, these figures have no predictive value. Moreover, even if corrupt practices were eliminated, many present-day impoverished nations will have inherited a building stock that to some degree incorporates the products of corrupt practices. The problem of what to do about these existing poorly built constructions is particularly difficult, if not economically insoluble.

But our analyses suggest that international and national funds set aside for earthquake resistance in countries where corruption is endemic are especially prone to being siphoned off. The structural integrity of a building is no stronger than the social integrity of the builder, and each nation has a responsibility to its citizens to ensure adequate inspection. In particular, nations with a history of significant earthquakes and known corruption issues should stand reminded that an unregulated construction industry is a potential killer. ■

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