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Anticipating the World's Most Expensive Natural Disaster

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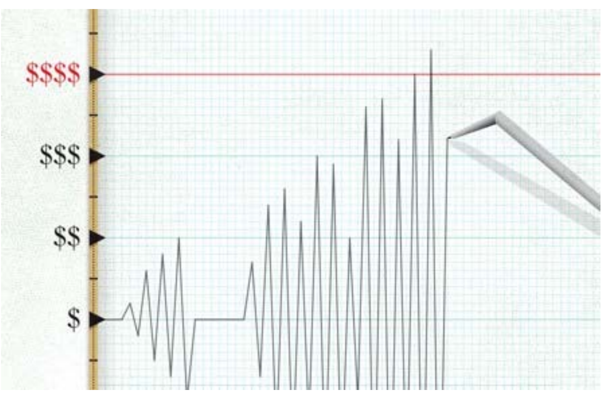
The next Tokyo earthquake will be the most expensive disaster in history.



The powerful earthquake and high tsunami that struck the Tohoku region of northeastern Japan in March 2011, and that led to the Fukushima nuclear disaster, have been a perfect demonstration of our unwillingness to take adequate preventive steps against known risks that return with a very low frequency but whose effect can be extraordinarily large. These risks range from local and regional (caused, most often, by heavy floods and major earthquakes) to global, including viral pandemics and an encounter with an asteroid—a very low-probability event that could instantly obliterate our civilization.

Japan stands alone among all modern, large, and affluent economies in facing an unpredictable but inevitable disaster. Unlike the United States, France, or Russia, the country lives with the terrible certainty that its capital, the world's largest megacity, will eventually be hit by a strong earthquake that will amount to the most expensive disaster in history. Washington can get an occasional heavy snowfall and it can be affected by hurricane winds and flooding. The Seine can submerge large parts of Paris (as it did in January 1910 and threatened to do in 2003), and unusually strong winds can topple trees that stood for more than two centuries (as happened in December 1999 when Versailles lost many of its ancient trees). Moscow is threatened by nothing worse than a severe winter or summer drought affecting the surrounding countryside and producing (as it did in 2010) massive forest and peat wild fires that veiled the city in heavy smoke for weeks.

All of these are damaging and costly but non-catastrophic natural disasters with relatively ephemeral socio-economic impacts. That will not be the case with the next major Tokyo earthquake. It will kill only a fraction of people that perished in the city's last great natural disaster, the earthquake of September 1, 1923, when collapsed buildings and extensive fires (in a still largely wooden city) killed about 140,000 people of the total population of nearly 4 million. But unlike the 1923 tremor that reduced the country's GDP by less than 5 percent, the next major earthquake will be the most expensive disaster in history when it strikes the world's largest megacity, which has a population of more than 33 million people.

This is the most sobering but incontrovertible starting point: When, not if. That is precisely why Japanese scientists and disaster experts have been developing realistic scenarios anticipating the extent and the consequence of such a disaster.

Thinking and writing about such matters is unsettling, but we have learned two great lessons from many modern disasters: 1) our response to them is always initially more chaotic and less effective than envisaged in model scenarios; but 2) a higher degree of preparedness can make a substantial difference, both in avoided death and injury and in property damage.

Earthquakes cannot be predicted, but probabilistic appraisals are another matter. Bozkurt et al. used more than 10,000 observations of earthquake intensity accumulated since 1600 to estimate that the probability of severe shaking in Tokyo is 30 to 40 percent during an average 30-year period. In 2006, the Earthquake Research Committee of Japan estimated the probability of an earthquake with the epicenter beneath northern Tokyo Bay at 70 percent in the next 30 years, with the area including Tokyo, Chiba, Saitama, and Kanagawa experiencing shaking of at least magnitude 6, and 25 million people, or 20 percent of Japan's total population, affected—an event unprecedented in global history.

In the constructed scenario, the earthquake occurs at 6 p.m. on a winter day and damage was calculated for two wind speeds: about 22 km/hour and for a very windy evening with 54 km/hour (the latter average being an unlikely maximum based on the wind speed during the Great Kanto Earthquake of 1923). This was the first time estimates were made for many types of damage a major earthquake would trigger in the world's largest metropolis. According to this scenario, there would be about 6,400 instant deaths (more than half of them due to fires) and more than 160,000 severely injured people, many of whom would die because they could not be rapidly transported to hospitals, and emergency wards would be taxed far beyond their capacity. Even with the city's extraordinary advances in earthquake-proof construction, the scenario expects about 462,000 damaged buildings (no tsunami would reach the city in this scenario).

Much larger numbers of people would be affected in many other ways, lasting hours to months. The city that is the global paragon of long-distance urban commuting would see both its highways and railways cut at more than 600 sites and would lose almost a fifth of its electricity supply (all subways and railways are electrified), and hence nearly 4.5 million people would not be able to return home. Even a day later, their number would be still just shy of 4 million. Should the earthquake happen during the coldest part of the year, the city would face a globally unprecedented task of finding emergency shelters for 4 million people who would also be thirsty and hungry.

The most pressing structural challenge would be to restore utilities. At least a third of water supply infrastructure would be damaged, as would close to 20 percent of natural gas flows and more than 20 percent of sewage facilities. The city would face the task of removing about 40 million tons of debris, mostly a jumble of concrete and metals. After 2011's Tohoku earthquake, the Cabinet Office for Disaster Management revisited these estimates, putting the death toll at 11,000 people, injuries at 210,000, collapsed buildings numbering more than 850,000 (650,000 due to fires), and the total economic loss exceeding ¥112 trillion.

With Japan's GDP in 2010 being about ¥540 trillion, the damage would be equivalent to at least 20 percent of the country's annual economic product. As already noted, the country's GDP (all figures adjusted for inflation) fell by less than 5 percent in 1923, the year of Tokyo's last great quake, and the war-induced GDP decline was on the order of 50 percent (no value is available for 1945 but in 1946 the economic product was 45 percent below the 1944 level). By any measure, a virtually instant loss of 20 percent of economic product in the world's third-largest economy would be a disaster of historic, and unprecedented, significance.

The latest assessment of potential damage from a major Tokyo earthquake, released in April 2012, has brought a few changes in its four scenarios. The worst case estimate has a higher number of deaths (about 9,700) than estimated previously, but about 170,000 fewer collapsed buildings (due to the disappearance of many old wooden structures and continuing reinforcement of newer buildings) and some 3.4 million evacuees. The scenario for the 8.2-magnitude quake also envisages a tsunami of up to 2.6 m flooding almost 5 km2 of the capital but unlikely to cause any deaths.

Should such a catastrophic disaster take place in the near future, it would set back Japan's economic progress for the rest of the decade. But the challenge of coping with its consequences would be even greater 20 to 25 years from now, when Japan will be a truly geriatric country. By 2035, Japan will have more people older than 70 years (about 29 million) than people in the prime of their lives, between 20 to 44 years of age. How would such a society cope with the devastation of its capital, largest city, and center of economic, cultural, and educational life? These are most uncomfortable, indeed terrifying, thoughts, but they remind us how fragile are the achievements of modern civilization and how uncertain are the fortunes of nations—particularly in places where nature repeatedly thwarts our designs.

Vaclav Smil does interdisciplinary research in the fields of energy, environmental and population change, food production and nutrition, technical innovation, risk assessment, and public policy.

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