

## ECONOMIC IMPACTS OF EARTHQUAKE PREDICTION

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In the United States, earthquake prediction is the responsibility of the U.S. Geological Survey. It supports fundamental researches - data-gathering activities in areas of high-seismic risk throughout the western United States, Alaska, northeastern United States, and Mississippi Valley - and cooperative research efforts with host countries outside of the United States. The principal goal of the program is to develop reliable methods for forecasting the time, place, and magnitude of damaging earthquakes. Two distinct strategies for obtaining the goals of the program are being pursued concurrently. The first is the development of a sound theoretical basis for earthquake prediction. This approach emphasizes developing a deeper understanding of the details of the earthquake cycle and earthquake recurrence and the physics of the immediate pre-earthquake failure process. Research activities include theoretical, experimental, and field framework studies. The second strategy follows an empirical approach, which seeks to develop a set of criteria for issuing predictions in probabilistic terms based on empirical observations of earthquake precursors. The criteria may employ poorly understood phenomena and observations that previous experience worldwide has shown to precede damaging earthquakes. Successful intermediate and short-term forecasts of damaging earthquakes in China, Japan, and Mexico have relied principally upon the empirical approach.

Impeding the rapid solution of the problem by either strategy is the lack of an adequate base of observations. This lack is particularly acute in the United States because of the short historical record for large earthquakes and the relative infrequency of such events compared to other parts of the world. More and better observations are vital prerequisites for progress and, therefore, constitute an essential activity of the earthquake prediction program. When the prediction research program was designed in February 1978, it was estimated that detailed observations of at least ten earthquakes of magnitude 5 or greater would be needed to establish the empirical and theoretical approaches. Since then, only three earthquakes of that size have been recorded within or adjacent to detailed networks of sensors.

Consequently, no official earthquake prediction has been made in the United States to date. In the meteorological field, however, we routinely issue predictions of the track and probable landfall of hurricane - designate areas of watch and warning for tornadoes - estimate flood levels of major rivers and tributaries for riverine floods - and issue warnings of flash flood on streams in connection with severe summer storms. We also accurately predicted the spectacular eruption of Mount St. Helens on May 18, 1980.

However, in summer 1982, as this symposium was being planned the United States Geological Survey issued a volcanic hazard notice for the eastern Sierra Nevada, another area with a history of volcanic and earthquake events.

The notice - the lowest of three warning levels - was based on the region's rising tempo of earthquakes, volcanic history, shifting hot spring patterns, and a 10-inch uplift on the floor of an ancient volcanic caldera. This notice is blamed in part for a 30-50 percent decline in business in the resort town of Mammoth Lakes, California, in summer 1982. Yet, no one knows how much of the decline was directly attributable to the notice and how much could be attributed to the recession and bad weather.

The economic impact of any prediction will vary with the accuracy of the prediction, length of time, region affected, population size, economy in the region, severity of the predicted earthquake, and above all- the greatest unknown - people and how they will react. The many random variables in any prediction situation and the great number of uncertainties leave us with more scenarios than plans, more questions than answers, as the Sierra Nevada incident suggests.

However, this much appears to be certain: the economic gains and losses resulting from a prediction will be felt most severely by individuals and small enterprises. Those living on fixed or low incomes, those depending directly on the local market for business, those having fixed rather than liquid assets, and those generally disadvantaged in our societies - those with language barriers, the handicapped, the minority groups - will be most affected. Much will depend on what decisions are made by the general public and the business and financial communities. People who need money in order to earthquake-proof their home, to relocate, or to take other precautionary measures may withdraw funds from checking and saving accounts to meet those needs. Some people may transfer their funds to safer areas or investments, fearing the impact of an earthquake prediction on local banks.

Each of these actions will have an impact on the community and, in turn, trigger other actions. Such actions will affect the ways in which financial institutions use their funds. Corporate loans to businesses whose earnings are likely to be disrupted by an earthquake will be placed in jeopardy. As business borrowing power declines, an economic slowdown and unemployment may impair the ability of borrowers to make payments on mortgages and consumer loans.

Investments in mortgages and local municipal bonds, which constitute a major portion of financial sector assets, will probably decline. The value of the banks' collateral can also be expected to decline as the local housing market deteriorates. Banks may restrict new mortgages in the area or require earthquake insurance. Holders of local municipal bonds face similar problems as the market freezes and interest payments are interrupted.

Not enough research has been done in the United States on the economic impacts of prediction, partly because, as I said earlier, we have had no earthquake prediction and most predictions of any disaster have been too short for the impacts to affect the economy significantly. An exception is a rural or resort area, such as Mammoth Lakes, where the economy is heavily dependent on the scenic environment and vacationers have not forgotten Mount St. Helens.

Our problem is made even more complex and difficult because of the impact of the actual event and the reactions that it can trigger. All 50 States have areas vulnerable to an earthquake and at least 30 of the States are subject to a major or moderate seismic risk. For example, an earthquake along the Mississippi river would not only disrupt the transportation of goods and have repercussions on trade centres such as Chicago, St. Louis, and New Orleans but transcontinental rail, vehicular travel routes and energy pipelines would be broken, thereby disrupting the supply of goods and energy resources throughout the country. Land telecommunications systems would be similarly affected, as would the ability of major financial institutions to transfer funds.

The impact of a prediction of such an event on our economy, and our many independent governmental units that would be involved - from federal to state to local, thus pose a particularly complex problem.

Therefore, rather than wait for a prediction and attempt to evaluate the many variables that would be involved and the effect of each on the environment, we have chosen to focus on preparing for and mitigating against the anticipated reactions.

There are basically three actions we can take to lessen the potential impact of an earthquake prediction: initiate changes, reduce losses, and absorb the losses. For example, we can change by abandoning the area of prediction or we can change our land use in the area. We can reduce losses by modifying the event, affecting the cause, and preventing losses. And we can accept the losses by simply bearing them or by sharing them through insurance mechanisms, public disaster relief, and personal charity. Clearly, some of these are not practicable. In the long term, we can modify our land use patterns, but probably not abandon the area - certainly not in California. Since we are so far unable to modify the event or affect its cause, we can only prepare ourselves for the event and mitigate its effects. While we must bear our losses to some degrees, sharing those losses as much as possible lessens the impact of the catastrophic events which from time to time affect each of us.

Based on our experience in all disasters, including our so-called "energy crisis", we have come to the following conclusions regarding how we can lessen the adverse impacts of an earthquake prediction. To begin with, predictions must be credible to the majority. If people are going to take the necessary actions to limit loss of lives and property. Disruption caused by panic or an inaccurate prediction, or apathy fostered by disbelief, will increase the adverse impacts unnecessarily.

Therefore, warnings must be issued effectively, reaching people in a manner that they understand and from sources they will accept. Statements must be issued in multiple languages and through numerous communications channels in order to reach all segments of society. Research in the social science field indicates that those in the lower-income segment of American society place more faith in announcements issued by an organization such as the Red Cross than in those issued by a government agency, or official, whereas those in the higher-income segment tend to believe government announcements.

In improving the reliability and authenticity of the prediction itself, some means of evaluating the predictions and issuing them via appropriate information routes must be developed. The United States has established a technical panel headed by the U.S. Geological Survey to assess the accuracy of all predictions.

It found to be valid, the U.S. Geological Survey issues the necessary warning through established channels, which will trigger the appropriate preparedness activities in state and local governments and emergency management networks, including such organizations as the Red Cross.

Once the prediction is issued the area's ability to cope with the actual event will have significant bearing on the impact of that prediction. For example, FEMA has begun a cooperative effort with these groups to evaluate the initial direct and indirect impacts of a major California earthquake event on the economy and industry at all levels. An evaluation of the damage and of the immediate economic impacts is underway and should be completed by January 1982, at which time an evaluation of the dynamics of economic recovery and change on the economy and industry will begin. Our efforts in assessing the economic impacts of a prediction are, however, still in the planning stage. In our efforts to lessen the economic and human impacts of an earthquake, we are utilizing experience gained from other disaster mitigation and preparedness efforts, such as our national flood insurance program. Such vulnerability and impact assessment are essential in order to mitigate the impacts of a prediction and event.

As in our flood and hurricane hazard mitigation efforts, we are working with state and local governments to identify the hazards and assess the potential impact and losses from earthquakes. That information then is used to develop contingency plans that address all elements of emergency management - mitigation, preparedness, response, and recovery - and take into consideration other events such as dam breaks.

By working with banking, insurance, and financial groups we can absorb expected losses in earthquake-prone areas. One stabilizing element is the present of mechanisms operated by the federal government to ensure solvency and liquidity to banks that are part of the federal reserve system or insured by a federal instrumentality. However, many other measures could also be taken to protect the financial community against adverse impacts. For example, banks in high-risk areas could be encouraged to diversify their mortgage portfolios in anticipation of an actual prediction. Earthquake insurance could be required on mortgages in risky areas. Emergency loans could possibly be extended to small businesses through the Small Business Administration. However, while a number of techniques and possible procedures exist, their implementation may be difficult, especially in a federal system.

Reducing the effects of a prediction and the event itself will also require pre-prediction mitigation efforts by state and local governments and the business community. Wise land use and proper construction to withstand the impact are required mitigation measures if insurance and banking groups are to continue to do business once an earthquake prediction has been issued.

For long-range mitigation purposes, the Interagency Committee on Seismic Safety in Construction (ICSSC) was formed in 1978 in order to standardize the seismic provisions used by federal agencies in their construction activities so that they would set an example for the private sector. A draft seismic standard for new federal buildings has been developed and disseminated. In conjunction with that and as part of the U.S. efforts to lessen the economic impacts of earthquake predictions and events, the Building Seismic Safety Council (BSSC) was formed in 1979 to provide a forum for the diverse elements of the nation's building industry. As a result, the BSSC has developed an improved set of provisions for the development of seismic regulations for buildings. After conducting design trials to determine engineering feasibility of various design features and the cost of applying them, the provisions will be published as a resource document for voluntary use by state and local building departments.

Parallel to FEMA's hurricane preparedness programme is the earthquake preparedness programme with its projects in high-risk/high-population areas. Of these projects the most extensive effort in earthquake preparedness planning at present is going on in the five counties of the Los Angeles metropolitan area, which includes the area of uplift known as the Palmdale Bulge. Here a joint state-federal activity, the Southern California Earthquake Preparedness Project (SCEPP) involves the participation of the general public, neighbourhood groups, industries, voluntary agencies and local authorities in preparing for and lessening the adverse impacts of both a predicted and an unpredicted earthquake of large magnitude. Although an official prediction has not been issued, geologists estimate that the probability of the occurrence of a large-magnitude earthquake is about 2-5 percent per year and greater than 50 percent in the next 30 years.

Through planning partner arrangements, SCEPP's prototype plans are being developed from the local level upwards to respond to local needs. SCEPP is not only facilitating the development of prototype plans for how an earthquake prediction would be validated and communicated to the general public and private organizations, but also how the region would respond to such a prediction and how the negative impacts could be minimized.

Our past experience has raised serious questions about the length of time required to draw the necessary attention to the earthquake hazard to obtain adequate responses to predictions. Moreover, it has raised doubts about our ability to sustain that awareness once it is developed.

Because predictions covering long time spans have generally been marked by considerable uncertainty, they have been greeted with scepticism in many segments of society. Therefore, securing adequate, constructive responses to future earthquake warnings will not be an easy task. Our experience with other disasters suggests that any warnings may be widely discounted and ignored and that inaction rather than panic flight will be the most common response.

Long-term predictions especially will impart a sense of unreality due to remoteness of the threat. Because of the absence of external signs through which people can confirm the threat with their own senses, credibility becomes a special problem.

Therefore, as a major factor in prediction and event response, public awareness and its impact on the economic and emergency management aspects must also be a major part of any mitigation and preparedness efforts. For this reason, we have begun a multi-year effort to prepare and implement a comprehensive earthquake education/information program for the general public and specific audiences. For instance, we will develop and provide educational materials on the causes and effects of earthquakes, on earthquake prediction, on life safety and earthquake preparedness and mitigation measures for all segments of society. We will enhance the dissemination and use of earthquake safety materials through outreach programs by volunteer organizations, associations, and youth and religious groups and through hazard mitigation workshops.

By protecting against inaccurate predictions, identifying the hazards and assessing the impacts of predictions and actual events, taking the necessary long-range preparedness measures to lessen those impacts, and developing public awareness, the adverse impacts of an earthquake prediction can be kept to a minimum. It is essential that all governmental and international groups, the business and financial communities, and the general public work together if that goal is to be met.

## DISCUSSION

Dr. Fournier d'Albe asked what could be the criteria for a useful prediction from FEMA's point of view. Mr. Krimm replied that long-range prediction would be relevant to long-range local and regional planning, while short-range prediction would be of greatest concern to FEMA. The Agency could take specific actions including evacuation, shutdown of nuclear power plants and so on.

Prof. Lomnitz commented on economic effects of earthquake in Latin America and Mexico. Some insurance problems were mentioned and were discussed in subsequent interventions by various speakers, including Messrs. Smolka, Roberts, Kárník, Krimm, Fournier d'Albe, Nigg, Tomblin and Suyehiro.

Dr. Suyehiro pointed out that the Japanese government is not liable for false predictions.

Prof. Lomnitz noted that preparedness problems in developing countries are of different dimension than in developed nations. Prof. Roberts pointed out that, ironically, safety regulations may distort the economy in a country. He asked Mr. Krimm about response to requests for assistance from State and local government. Mr. Krimm provided information on the diversity of response according to economic needs.

### N.B.

Mr. Thomas was unable to attend the seminar. His paper was read by Mr. Krimm, who also answered questions during the discussion reported above.