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A REVIEW ESSAY ON PANEL ON THE PUBLIC POLICY IMPLICATIONS OF EARTHQUAKE PREDICTION, *EARTHQUAKE PREDICTION AND PUBLIC POLICY* (Washington, D.C.: National Academy of Sciences, 1975), 142 pp., $ 6.50

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What is the first thing you should do if you were a mayor who had just been notified by the governor that your city was in an area in which there was a fifty percent probability of a Richter magnitude 7 earthquake occurring between Labor Day and Christmas of 1983? If you answered: "Sit down and read the National Academy of Sciences' report on *Earthquake Prediction and Public Policy* from cover to cover," then give yourself fifteen bonus points and proceed.

Prospects that in the not-too-distant future earth scientists will be able to forecast the time and location of damaging earthquakes (those above Richter magnitude 6) seems like a rather innocuous if not welcome development. It may come as a surprise therefore to learn that there are individuals who say "In vulgar language, we need an earthquake-predicting facility like we need a hole in the head" (Hardin, 1973: 133). Other groups such as the California Business Properties Association are more subtle in their expressions of concern but make the point rather firmly that this new technology threatens some deeply-held interests (Cook, 1975). What's going on here?

Earthquake predictions are unique and worrisome because they are likely to differ in several ways from warning-and-response processes associated with other types of natural hazards. For instance, those tell-tale changes called "premonitory signs" which indicate the beginning of a causal chain eventually culminating in the occurrence of an earthquake may occur *decades* before impact rather than a few hours or days as in the case of tornadoes, floods, hurricanes, and the like. Will this mean that information about the prediction will enter into decisions to buy or sell a house, to locate a business, or to market insurance in ways that the threat of other hazards does not? The so-called "time window," that period in which a predicted quake is expected to occur, will likely range from a matter of a few weeks for smaller magnitude earthquakes to a year or more for larger ones. Should cities be evacuated until the time window has passed? Or should schools be closed at least? There is an additional factor complicating the earthquake hazard for, unlike most other natural disaster agents, evidence that one is on the way (or that conditions were right for one that did not occur) will be evident only to a handful of individuals in the scientific community. Generally visible precursors such as rain before a flood or green skies and hail before a tornado will be absent. And a final twist to the plot adds a further dash of uncertainty. The infrequency of the very largest quakes (e.g., those of Richter

magnitude 8 or greater) means not only that they are difficult to study but also that any prediction of a major earthquake will likely be the first for a given community which therefore will have no reservoir of similar prediction experiences to draw from.

Recognizing the unique and serious nature of issues surrounding this new technology of earthquake prediction, the National Academy of Sciences moved on two fronts in the early 1970's to address the topic. Its Committee on Seismology organized the Panel on Earthquake Prediction to evaluate the current physical science state-of-the-art of predicting earthquakes and to assess the prospects for development of this technology in the near future. (Findings and recommendations from this Panel will not be described here; see Panel on Earthquake Prediction, 1976.) The Panel on the Public Policy Implications of Earthquake Prediction was organized in the spring of 1974 under auspices of the Academy's Advisory Committee on Emergency Planning. Chaired by Ralph H. Turner, sociologist from the University of California at Los Angeles and a member of the Advisory Committee, the Panel consisted of eight members assisted by thirteen liaison representatives and three consultants and represented a variety of academic disciplines (sociology, political science, economics, law, and seismology) as well as earthquake engineering, disaster preparedness and relief agencies, and the private sector. With initial funds from the Federal Disaster Assistance Administration (Department of Housing and Urban Development), the Panel sought to identify social, economic, legal, and political issues surrounding the implementation of this new earthquake prediction capability which might be the basis for both the formulation of public policy and for recommendations for future policy-relevant social science research. Its final report, *Earthquake Prediction and Public Policy*, is thus addressed not only to an audience of local, state, and Federal governmental officials but also to individuals from the business and private sectors, social scientists and researchers, and interested citizens in general.

With such serious issues and questions surrounding its use as those mentioned above, one might well ask: Is earthquake prediction a good thing? The Panel responds in several ways. First, earthquake prediction is inevitable. Given the nature of science and of scientific work in the United States, suppression of earthquake prediction research would not only be objectionable but unsuccessful as well. The only consequence might be to delay its development (pp. 31–33). Hence this question is of secondary importance if not irrelevant. Second, ability to predict earthquakes clearly offers the opportunity to save lives and reduce physical injury, although prospects for reducing property loss due to earthquakes are less certain (pp. 3, 119). But third, appropriate action by public officials at local, state, and Federal levels together with business, financial, and labor leaders now and as the forecasting technology develops can forestall or at least lessen the feared economic and social costs of predictions (p. iv; see also pp. 119, 138).

The scope and something of the substance of the Panel's report is exposed by describing its handling of three topics central to any discussion of the use of a routine earthquake prediction capability. (An excellent condensation of the report, including all its policy and research recommendations, appeared in an earlier number of this journal; see Turner, 1976a.) First, the earthquake hazard is at base a problem of hazardous man-made structures. That is, the primary threat to human safety in earthquakes arises from the failure of buildings (p. 36), with secondary threats posed by damage to lifelines such as dams, bridges, and gas transmission lines (p. 37). The real villain of the piece though is the multi-unit building of unreinforced masonry construction (p. 39); what to do about such structures and their occupants when a future earthquake is expected is a question running through several chapters of the report. The State of California adopted seismic-resistant building regulations after the 1933 Long Beach earthquake, and new construction since that time places that

state ahead of others in the East and the Midwest in terms of building safety, but still there are an estimated 40,000 unreinforced masonry buildings in Los Angeles County alone (p. 38). The scope of the hazard broadens when one realizes that earthquakes are not just a California problem, jokes about the San Andreas Fault and ocean-front property in Nevada to the contrary; only eight percent of the population of the United States is not exposed to the threat of earthquakes (p. 20). In fact, such major population centers as Charleston, S.C., the St. Louis-Memphis area, Boston, Salt Lake City, and the Puget Sound region are all significantly exposed to the earthquake threat. Earthquake prediction, therefore, is a potentially significant development for the nation as a whole, not just California although the capability for routine prediction will likely emerge there first (due to the frequency of small earthquakes for study and the relative density of current instrumentation; pp. 25–26).

Without mentioning the sometimes passionate debate between those who argue that the most appropriate attack on the earthquake problem is through engineering, building code enactment and enforcement, and land use planning and those who argue the merits of earthquake prediction, the Panel makes its position clear: "[p]rediction should be used in conjunction with a complete program of earthquake-hazard reduction, and not as a substitute for any of the procedures in current use" (Recommendation 2, p. 4) and "[p]rediction capability does not lessen the importance of other approaches to earthquake mitigation" (p. 24). Once a prediction has been issued, however, the Panel identifies several types of constraints on the choice among mitigation strategies and their implementation. An obvious one is the amount of time between the issuance of the first prediction and the beginning of the time window in which the quake is expected to occur. Consequently the Panel is careful to distinguish between steps to be taken with one or more years of advance warning from those available with less than one year lead time (see especially the final chapter, pp. 120–137). Even with sufficient time, however, very real constraints will come into play in dealing with the problem of hazardous buildings. A careful assessment of laws regarding property rights suggests the general conclusion that government's ability to deal with existing structures is limited (pp. 85–92). In addition, the costs of a massive building safety campaign are likely to be beyond the means of most local and even state governments (p. 111). Furthermore, systematic review of existing studies of evacuation in natural disasters and wartime suggests that use of this strategy on a massive scale is politically untenable (pp. 112–113) and otherwise extremely costly as well (pp. 131–134). Based upon these evaluations, the Panel urges allocation of Federal emergency funds such as provided under Public Law 93-288 *before* the onset of an earthquake to help overcome local economic hardships resulting from the prediction (see Recommendations 5 and 15, p. 7 and pp. 14–15). And it recommends selective evacuation and systematic vacating of unsafe structures since the limitations on other strategies will mean that many of these will remain.

A second topic indicative of the scope of the Panel's concerns is "how to release earthquake predictions and warnings in such a way that the response will be constructive and not counterproductive" (p. 47). One thing the Panel absolutely insists upon is the early and widespread dissemination of any prediction to prevent those with "inside information" from benefiting at the expense of others (p. 77; see also Recommendation 7, p. 9). Public officials should not be afraid to release such information if they fear it will cause widespread panic since there is abundant evidence from over twenty-five years of disaster research that such fears are unfounded (p. 48). Furthermore, scientists issuing an earthquake prediction and public officials issuing a warning are very unlikely to be held legally liable when both are

acting in good faith even if a prediction were to prove erroneous; the same may not be true if scientifically credible information is withheld, however (pp. 81–85). This legal assessment is especially germane since officials are instructed to assume that "occasional disruptive and expensive false alarms are unavoidable" and that "some major or moderate earthquakes may occur without advance notice" (p. 30).

If public officials and scientists need not worry about widespread general panic, the Panel's careful examination of the disaster warning-and-response literature suggests that they should be concerned about citizens tending to ignore the warning altogether, i.e., "to disbelieve the prediction, minimize the danger, and view the situation optimistically" (p. 50). Furthermore, the report suggests that the greatest single difficulty in the warning process will come in prompting appropriate responses from those outside the mainstream of the community such as the elderly, the handicapped, low income populations, tourists, and members of various ethnic and minority groups (p. 52). Placing such peripheral segments of the community on center stage is one of the impressive aspects of the Panel's report; it especially worries about the unequal distribution of the costs of earthquake prediction (physical, social, and economic) which might be disproportionately borne by such relatively powerless groups (see below).

A third topic receiving extended attention is that of dealing with the economic costs of a prediction at the local (or regional) level. What the exact nature of a region's economic reaction will be when the earliest earthquake predictions are forecast with some degree of credibility is far from clear at this point (p. 70), but reading between the lines of the report it appears that one of the keys will be the reaction of non-local businesses, those whose sales are not exclusively tied to local income and employment conditions (p. 72; see also pp. 100–101). There appear to be inevitable costs to the economy of the affected region, but their extent can be altered by Federal policies regarding insurance and emergency aid for the pre-impact period since banks, lending agencies, and insurance companies at the regional level react to such policies (see pp. 72–77).

As earlier when considering personal safety, here regarding economic impact the Panel squarely addresses the issue of the possible uneven burden of costs. One sure way to see that costs will be inequitably distributed would be to allow profit-seeking speculators access to prior information about the prediction (pp. 77–78, 98–99); hence, a relatively simple way to make it more difficult for some to benefit at the expense of others is to insure that all information regarding the prediction is quickly and completely released. Of course, communities are highly differentiated rather than monolithic social constructions; some groups (e.g., the illiterate, tourists, foreign-speaking, the isolated, the hearing-impaired) will be harder to warn than others, some are more likely than others to be living in the most vulnerable structures (e.g., the poor, the elderly, minorities), and some will have greater difficulty recovering from the effects of any catastrophe than others (e.g., the infirm, the aged). The Panel devotes a separate chapter to these issues (pp. 96–104) and notes a hidden danger which might arise from unintended consequences of the most well-intended hazard mitigation programs (pp. 103–104). It urges that programs for offsetting inequities which might surface be designed so that they do not paradoxically provide incentives for maintaining the status quo or even increasing the inequitable exposure to risk (e.g., land use and building code ordinances which drive up the cost of housing and force low-income families in greater numbers into vulnerable multi-unit buildings).

There seem to be two major ways to evaluate a report such as this. One is to examine its relevance in the implementation of the new technology of predicting earthquakes. The

accuracy of the report in anticipating patterns of response to early earthquake predictions and the extent to which suggestions from the report are taken into account are two contemporary indicators of the report's relevance, although its ultimate impact cannot be assessed until the new technology has been in place for several years. A second is to compare the report with others on the same topic or with other hypothetical reports which could have been written. Both will be utilized in the space which remains.

Many of the Panel's projections have already proven to be accurate, and some of its fears also seem well founded. Soon after a university scientist publicly issued what many interpreted as an earthquake prediction (he himself called it an "hypothesis test"), one Los Angeles City Council member instructed the City Attorney to file suit against the scientist and his university for adversely affecting property values in the forecasted area. (No legal action was taken by the city.) Subsequently the State of California passed an earthquake prediction liability bill in an effort to protect those involved in the prediction and warning process (S.B. 1950, 1976; see Recommendation 7, p. 9 and pp. 81–85). The same forecast (officially labeled an "area of intense study") was followed by unconfirmed reports that the three largest sellers of homeowners' insurance temporarily suspended sales of new earthquake policies and riders on existing policies for homes in the area (see pp. 74–76). More recently, a Los Angeles City Council ordinance to require improving hazardous buildings or tearing them down was withdrawn to committee in the face of highly visible opposition from business interests and minority tenants. A second ordinance was approved, calling instead for an inventory of the exact number of such hazardous structures, suggesting that the Panel's identification of the importance of grassroots political support for hazard mitigation programs is highly appropriate in the post-prediction situation (see pp. 114–115, 109–110).

Actually, evidence that the report was to have an impact was at hand even before it had been published. In a six-page cover story on earthquake prediction, *Time* magazine (1975: 36–41; see p. 41) reviewed the principal conclusions of the Panel apparently from a draft of the final report. Other evidence of the report's impact comes from the State of California's Earthquake Prediction Evaluation Council which, both in its deliberations and in the formulation of formal guidelines and procedures (Office of Emergency Services, 1977), has incorporated several implicit and explicit suggestions of the Panel. And there has been at least one effort to clarify existing Federal legislation regarding the use of disaster relief funds before an earthquake but after a prediction. Following disclosure of an "earthquake prediction hypothesis test" (see above), the City of San Fernando, California which was located in the center of the area where a quake would have been expected, requested clarification "of any existing programs in the area of preparedness, with primary concern being directed towards the area of preparedness prompted by the emergence of earthquake (sic) prediction as a factor" (Harris, 1976). The issue, however, remains essentially unresolved for, as the director of the Federal Disaster Assistance Administration notes in his response, the situation is not one in which an official earthquake prediction has been issued and thus "preventive action today must be against a general threat of earthquake rather than against one predicted to occur at a specific location and time" (Dunn, 1976). Most recently, the City of Los Angeles established a twenty-five member Mayor's Task Force on Earthquake Prediction to recommend ways for the city to respond to a future scientifically validated earthquake prediction (Turner is a member of the Task Force).

On other fronts, events have gone generally as the Panel might have wished them, but it is difficult to demonstrate that this is a direct result of the report itself. For example, two major earthquake prediction bills, one in the

Congress (see S. 126) and one in the California State Senate (S.B. 135), each have emphasized development of operational earthquake predicting systems as well as earthquake prediction research, but the Panel recommended that "At the present stage in the development of prediction, a higher priority should still be placed on research into earthquake prediction than on the establishment of operational systems for prediction" (p. 3). In fact, earlier versions of both bills were defeated largely on grounds that development of such operational systems was premature (see, for example, U.S. Congress, 1976: pp. 38–41). Although the Panel recommends formation of Federal-level group of experts to evaluate predictions outside of any agency with its own earthquake prediction mission (Recommendation 8, pp. 9–10), the Geological Survey thus far has been the only agency to form such a body both to review prediction evidence from USGS scientists and to "look at predictions by non-survey scientists on request by a State or Federal official" (U.S. Department of the Interior, 1976a, 1976b). (Also, compare language proposed in its guidelines, U.S. Department of the Interior, 1977: 19294-19295 with that in the Panel's report, pp. 64–65.)

There have also been some developments regarding policy-relevant research recommended by the Panel. Chief among these has been the establishment of a Committee on the Socioeconomic Effects of Earthquake Prediction within the Commission on Sociotechnical Systems of the National Academy of Sciences to spell out in more detail appropriate methodologies and hypotheses for the fourteen general research recommendations in the Panel's report. This Committee has expanded upon recommendations for establishing a standby anticipatory research capability and data needs in the area of baseline socioeconomic data on communities, for studies of legal problems, governmental responsibilities, and intergovernmental relations, and for a variety of responses to predictions by markets, corporations, and families all largely informed by an information processing framework (see the Committee's forthcoming report which will appear in 1978).

Several of the Panel's research recommendations have already been incorporated into a research project directed by Turner himself, in particular those concerned with the dynamics of credibility of predictions and with popular perceptions of earthquake prediction information in survey research being done in the Los Angeles metropolitan area (Research Recommendations 2, 6, and 8; see Turner, 1976c). And inquiry into the experience of other nations with earthquake predictions (Research Recommendation 3) has begun, first within the previously-funded research by Haas and Mileti (1976) and later in Turner's personal visit to the People's Republic of China as part of a scientific exchange delegation in June 1976 (see Turner, 1976b).

The second method of evaluating this report is to compare it with others which have been prepared on the same topic. There have been three other assessments of the issues and concerns likely to surround implementation of this new capacity for routinely forecasting earthquakes, and the Panel's report fares very well indeed in comparison with them. Jones and Jones (1975) develop several "action options" from three prediction scenarios varying primarily in length of lead time, severity of predicted quake, and length of operating experience of the prediction system. While the evolutionary nature of the three models taken as a whole does provide a developmental flavor to the implementation of a new technology generally absent from the Panel's report, the latter has a much firmer empirical base, is much more precise in its identification of problem areas, and is much more sophisticated and detailed in its suggestions and policy recommendations. Identical comments could equally describe the comparison of the report of a technology assessment by the Stanford Re-

search Institute (Weisbecker et al., 1977) which additionally has more of the flavor of a shopping list of things to be considered in developing policies around the new technology.

Only the empirical assessment by Haas and Mileti (1976) has had and likely will have in the future an impact at least in the public policy realm approaching that of the Panel's report. Haas and Mileti drew a purposive sample of several dozen public and private organizations and a random sample of 246 families in various sections of California and presented representatives of each with two scenarios of earthquake predictions. Respondents were asked what his or her group would likely do under conditions described in the scenarios. Data were then used to formulate predictive hypotheses of the likely consequences of future earthquake predictions. Many practitioners, particularly those in California, seem especially impressed by the picture painted by the Haas-Mileti study despite the "What would you do if ...?" character underlying the results apparently because these were drawn from original data rather than by inference from research on other problems. On balance, however, the findings from this projective approach and those of the Panel based upon inferences from previous disaster studies and research on slowly developing social problems are similar, and each report touches on many of the same policy issues as key to the outcome of the implementation process.

Compared with other reports which could have been written, this one also fares very well. Some practitioners have complained that the Panel's report is too superficial, that it does not go far enough. What many seem to be saying is that the report is long on identifying potential trouble spots but short on identifying solutions to them. But members of the Panel would probably respond that this is the first step and proof that they have accomplished their work successfully, that solutions will depend on further developments, on the specific histories of predictions in a particular community, and on the outcome of policy-relevant research such as that proposed in the report itself. This criticism seems to reflect, in other words, a misunderstanding of how best to use the report as well as left-handed proof that the Panel has done its job well.

Another more substantive criticism has come from some members of the scientific community who see many of the Panel's conclusions and suggestions as biased by the type of assumptions made about the nature of earthquake predictions when they are first made, especially regarding the length of lead time available. But this point is well taken only to a degree. The Panel does consider both long lead times (more than a year) and short lead times (less than one year), but does not consider lead times of only a matter of days, probably because this very short period of forewarning would place earthquake forecasts squarely within the confines of other types of natural hazard warnings about which a great deal is known, hence minimizing or eliminating several of the unique features making earthquake predictions and warnings an issue of policy concern (see above). Additionally, the Panel had access to preliminary findings from the earlier Panel on Earthquake Prediction (1976) from which presumably came the model of earthquake predictions used in the report (pp. 26–31). This type of criticism from earth scientists is inevitable since there is no consensus over the exact nature of routine predicting when it develops (p. 25) nor for that matter is there total consensus among scientists that the goal of earthquake prediction will ever be successfully achieved.

It might sound like a "cheap shot" to criticize such a report as this for not considering all the complexities involved in such a complicated matter since obviously some simplification was necessary if any document was to be produced at all. But there is one area where the report could have been usefully strengthened which would have been especially relevant to practitioners and policy makers. At various

points the Panel notes that experiences with later predictions will differ from experiences with the first ones (e.g., p. iv), but, like the Haas-Mileti project, attention probably unavoidably centers on what happens after scientifically valid predictions become available as well as what to do now to prepare for that day without addressing the question of what to do in the meantime. (The Panel does not assume that the first predictions will be automatically or self-evidently credible; see Research Recommendations 6 and 8, p. 12). The interim period (that is, the present and near future) is the gray area, the period of in-betweens filled with "areas of intense study," "earthquake prediction hypothesis tests," and the predictions of prophets, seers, and amateur scientists (see p. 30) which are, if not everyday occurrences, at least rather frequent especially in California. (One interesting prediction by a witch which was partially supported by a university scientist has been recorded in North Carolina; Mileti, 1977.) Many officials have difficulty in sorting through all of this, in deciding what to tell concerned citizens, and in deciding on appropriate courses of action for their jurisdictions.

Earthquake Prediction and Public Policy is an impressive document in all respects. Perhaps the highest compliment which can be paid is that it both does not read like the product of a committee while at the same time it reflects the pooling of concentrated work by some of the most competent people in their respective fields. That the report exists at all can in part be attributed to the National Academy of Sciences which provided additional funds for staff support and for publication after support from FDAA expired before completion. That the report has the high quality, both stylistically and substantively, can be attributed to laborious efforts by the Panel's chairperson, Ralph Turner, and by its executive secretary, Charles Fritz. Several members of the Panel and liaison group have commented especially on the contributions of Turner to each of the sessions when the Panel met and to the manuscript which was ultimately published. The document is commonly referred to as "the Turner report," a shorthand designation which, without slighting the contributions of others in any way (see Turner, 1976a: 202, footnote 1), seems highly appropriate.

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