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FRBSF Weekly Letter

Earthquake Economics

Much of the United States is seismically active, but the greatest earthquake risks prevail in the western states (see map). Virtually every major metropolitan area west of the Rockies is in a high-risk zone, facing the potential of catastrophic losses. Estimates by the United States Geological Survey (USGS) suggest that a great earthquake in San Francisco today would cause 11,000 deaths, 44,000 hospitalizations and about $40 billion in property damage. A similar event in Los Angeles would generate 23,000 deaths, 91,000 hospitalizations and almost $70 billion in damage.

Against this background, it is sometimes surprising to learn that the marketplace does very little to accommodate earthquake risk. Despite the fact that over 150 carriers offer earthquake insurance coverage in California, for example, less than 6 percent of the households carrying home insurance regularly purchase it. Nor do mortgage lenders, whose assets are secured by real estate subject to earthquake risk, routinely protect their portfolios with insurance. (Although a fire-coverage requirement is quite standard in mortgage contracts, no such requirement is widely applied in regard to earthquake risk.) Similarly, real-estate investors and builders often balk at incorporating earthquake-resistance measures in construction projects.

Earthquake risk

Decision-making under earthquake risk, of course, is influenced by the tremendously powerful and damaging nature of earthquakes. The great Anchorage (Richter 8.6) earthquake of 1964, for example, moved a 40,000-square-mile chunk of the earth's crust, thrusting it upward by as much as 30 feet in some places. Even in the comparatively moderate (Richter 6.6) San Fernando Valley event of 1971, some structures experienced ground-motion acceleration in excess of one "g"—meaning horizontal forces equal to the full force of gravity.

Even well-built structures will be severely damaged by such forces, although much depends on the type and quality of construction. Engineering data suggest probable maximum losses of 7 to 15 percent of value for typical residences and other wood-frame construction, 20 to 35 percent for steel-frame buildings, and 25 to 85 percent for concrete and masonry construction of various qualities. Loss of life will, in turn, likely be greater in the more severely damaged structures.

But significant earthquakes are also relatively infrequent. Indeed, there has not been a major earthquake in any densely settled region of the country since the great San Francisco earthquake of 1906. Even in the shaky Far West, the probability of a great quake in any given year is quite low—two to five percent in the Los Angeles area and one percent in San Francisco, according to USGS estimates.

Decision-making and risk

Earthquakes may thus be characterized as low-probability, high-loss events. The conventional economic analysis of decison-making under such conditions employs the "expected utility" theory that Milton Friedman and Leonard Savage developed in the 1940's. According to this theory, individuals weight the *psychic value* of alternative outcomes (rather than the outcome itself) by the probabilities of occurence of each outcome. Risk-averse individuals assign a smaller psychic value (or utility) to a dollar gained than to a dollar lost, while the opposite is true for risk-takers.

Expected-utility theory indicates that risk-averse individuals should desire to purchase actuarially fair insurance to protect themselves from low-probability catastrophic losses that they could not easily bear themselves. (Actuarially fair insurance is insurance which has a premium equal to the probability of the event times the value of the

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loss.) Since most economists view the household as a risk-averse entity, the lack of consumer enthusiasm for earthquake insurance (and catastrophe insurance in general) thus comes as something of a surprise.

The problem may lie with the theory. Indeed, economists Danial Kahneman and Amos Tversky have found fault with the Friedman-Savage approach, on the basis of evidence from behavioral experiments and markets for other kinds of insurance. In particular, they find that people underweight remote events, leading to greater risk-taking than would otherwise be expected.

Howard Kunreuther of the Wharton School, in a similar vein, argues that the expected-utility theory operates only in an unreal world of perfect rationality and information. He argues that people may behave according to "bounded rationality," reluctant to purchase insurance or take other preventive steps because of limited knowledge of the nature of the catastrophe. For example, even the availability of heavily subsidized catastrophe insurance has failed in some major instances to encourage individuals to protect themselves from risk. Although the residents of Rapid City, Iowa, qualified for subsidized National Flood Insurance, only about 30 policies were in force there when the flood of 1971 caused $160 million in damage to the community.

Earthquake insurance

Nonetheless, we should not ignore more conventional explanations for the relatively low level of private hazard-mitigation efforts. For example, premiums for earthquake insurance may not attract even rational and well-informed individuals. Indeed, catastrophe-insurance coverage poses special problems. Coverage tends to be concentrated in risk-prone areas—three quarters of all earthquake-insurance policies are written in California, for example—so that the insurer cannot reduce the cost of coverage by diversifying risk geographically. In theory, insurers could accumulate sufficient reserves to protect themselves against the financial effects of massive claims, but they don't have enough experience to guide them in this area. In addition, U.S. tax laws don't adequately discriminate between catastrophe reserves and normal profits, as, for example, the Swedish and Mexican tax codes do. Thus, in those years when no claims are filed, insurers are unable to set aside reserves for future contingencies without tax liability.

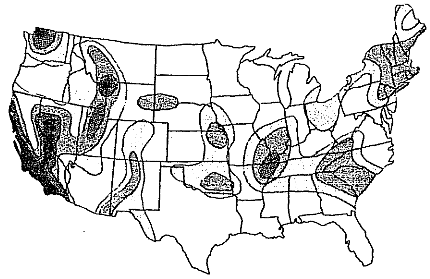
Such factors will, of course, affect the cost of earthquake coverage. The typical policy for a wood-frame residence in California costs $2 per year for each $1,000 of coverage, with a 5-percent deductible and an 80-percent coinsurance provision. The attractiveness of this type of policy to individual homeowners depends upon their risk-averseness and the expected frequency and size of losses. Experience suggests that wood-frame residences will suffer earthquake losses, on average, of 7 percent of value. (That was the average near the epicenter of the San Fernando earthquake, although 50-percent losses were not uncommon and a few total losses were recorded.) Under these conditions, the current typical premium structure would be actuarially "fair" for an annual-event probability of 8 percent. This is higher than current earthquake-probability estimates, and thus tends to make coverage less attractive to all but the most risk-averse households.

Low utilization of earthquake insurance thus seems to be a problem of weak demand at current premia rather than lack of awareness that coverage is available. Indeed, one insurer mounted a major marketing effort after the San Fernando earthquake and sold less than 100 policies. On the other hand, insurers probably could not offer coverage if people took a sudden interest in earthquake insurance, because existing reserves could not adequately support greatly expanded coverage.

Disaster aid

Other considerations may also act to discourage private mitigation efforts. For

Earthquake Risk Map of the United States



Darkest areas indicate highest risk
Source: Applied Technology Council

example, the Federal government provides liberal disaster relief, mostly through the provisions of the Federal Disaster Act and the emergency-lending powers of the Small Business Administration (SBA). These programs are activated by a Presidential designation of a region as a disaster area.

After the Anchorage earthquake of 1964, for example, the SBA loaned funds at 3 percent both to repair structural damage and to retire outstanding mortgages. Similarly, in 1971, it made special low-interest loans and outright (forgiveness) grants to uninsured earthquake victims in the San Fernando area. Such public-policy conventions, humane as they may seem at the time, actually increase further catstrophe potential by reducing the attention paid by private parties to risk exposure.

Building economics

The insurance market is not the only private activity which pays insufficient attention to earthquake risk—building design is another. Since falling structures are the major source of economic disruption and loss of life in an earthquake, it is interesting to consider the economics of earthquake-resistant design.

Even in the absence of building codes, potential liability for injuries and loss of life incurred by buildings' occupants should encourage architects and builders to employ earthquake resistant design. However, the courts have seldom found a builder or designer liable for casualties arising from the collapse of a structure affected by a catastrophic natural force. (In contrast, the ancient Babylonian code of Hammurabi held the builder liable with his own life!) Considering the uncertainties involved, such a legal position is understandable, but it serves to weaken private incentives to incorporate special earthquake-resistance features in new construction.

Moreover, designers often have no economic rationale for adding earthquake resistance to structures to avoid purely structural losses, especially in the case of renovation. Los Angeles County, for example, recently found that the cost of bringing 8,000 hazardous structures up to current standards would be roughly 70 percent of replacement cost. Given the low probability of a damaging earthquake in any one location, building owners clearly were better off risking the total loss of their properties.

Even for new construction, the cost of adding earthquake resistance could be a significant fraction of the cost of construction—perhaps greater than the expected value of the loss that would be incurred without such protection. Reducing the 20-to-35 percent probable loss to a conventional steel-frame highrise, for example, might raise construction costs by 10 percent or more. Given a less than 50-percent probability of earthquake in a building's lifetime, investors may not consider the additional construction costs warranted, particularly since the possible dollar losses may occur well in the future. Much depends, of course, on the type of structure involved and the risk-averseness of the investors. (Construction insurers report, for example, that Eastern investors are more concerned than Western investors about earthquake damage.) But private incentives to add earthquake resistance generally are rather weak.

Conceptually, the burden of coping with catastrophes such as earthquakes need not be thrust entirely on the public sector. If private-market participants accurately perceive risks and potential losses, and perceive that they will bear all associated costs, they will devote appropriate resources to avoiding or mitigating catastrophic events. Unfortunately, public disaster-compensation systems, limited builder liability, and other cited factors may lead the private sector to commit insufficient resources to the mitigation of such hazards. If, in addition, individuals systematically underweight high-loss, low-risk events—as some research suggests—both the public and the government may be surprised by the magnitude of their losses in the next major seismic event.

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BANKING DATA—TWELFTH FEDERAL RESERVE DISTRICT

(Dollar amounts in millions)

Selected Assets and Liabilities Large Commercial Banks	Amount Outstanding 9/30/81	Change from 9/23/81	Change from year ago Dollar	Change from year ago Percent
Loans (gross, adjusted) and investments*	153,294	1,400	11,183	7.9
Loans (gross, adjusted) — total#	132,395	1,409	12,261	10.2
Commercial and industrial	40,231	945	4,864	13.8
Real estate	54,575	116	6,087	12.6
Loans to individuals	23,211	172	– 833	– 3.5
Securities loans	1,532	– 2	591	62.8
U.S. Treasury securities*	5,673	– 42	– 877	– 13.4
Other securities*	15,226	33	– 197	– 1.3
Demand deposits — total#	42,377	3,543	– 4,835	– 10.2
Demand deposits — adjusted	28,630	1,628	– 5,370	– 15.8
Savings deposits — total	29,526	215	– 576	– 1.9
Time deposits — total#	85,200	– 87	20,687	32.1
Individuals, part. & corp.	77,292	110	21,347	38.2
(Large negotiable CD's)	33,858	– 60	9,041	36.4

Weekly Averages of Daily Figures	Week ended 9/30/81	Week ended 9/23/81	Comparable year-ago period
Member Bank Reserve Position			
Excess Reserves (+)/Deficiency (–)	n/a	59	96
Borrowings	148	53	188
Net free reserves (+)/Net borrowed(–)	n/a	5	– 93

* Excludes trading account securities.

\# Includes items not shown separately.

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