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The earthquake that struck the Japanese port city of Kobe in the early morning of January 17, 1995, was the most severe quake ever to strike a modern urban area. It has become the most studied, analyzed, and discussed natural disaster in history. What I propose to add to this dialogue is an economist's overview of what he saw in Kobe 19 months after the event and what he learned during the ensuing 6 months. I will offer my interpretation of the events, both leading up to and following the quake, in terms of basic economic principles. These principles are old hat in economics, but are not, as a rule, applied systematically to natural disasters. They will have, I think, some useful implications for how Japan and other countries might prepare for and respond to disasters in the future.

First, a few words about the quake. The brunt of it was felt in a swath roughly 20 kilometers long and 2 kilometers wide within a populated area of 4 million people. The intensity of the quake as measured by the Richter scale, 7.2, does not capture its full force since it was accompanied by an extraordinary horizontal movement of 1.5 to 2 meters, a vertical thrust of 1.2 meters, and a twisting motion as well. The port facilities, comprising the world's sixth largest container port, were a shambles. In the city, 100,000 buildings were completely destroyed, another 107,000 half destroyed, and 183,000 partially destroyed [32, p.59]. The entire underground water system was ruptured, as was much of the sewage system, the gas system, the power system, the rail system, and the main coastal highways, one elevated section of which simply rolled over on its side. Hundreds of fires broke out, mainly in the older industrial and residential sections of the city, and burned uncontrollably because backup water supplies were either inadequate or nonfunctioning. [6][11][25][26][28][32]

Over 300,000 people became homeless on that cold January day. Sixty-five hundred people died as a direct result of the quake; perhaps 600 or 700 in the fires, the rest from collapsing structures.

The damage to the capital stock came to about US\$100 billion, more than three times the cost of any previous natural disaster in history (although if currencies are valued at purchasing power parity, the dollar total would be considerably less). In terms of the loss of human life, however, Japan and the rest of the world have experienced far worse. The 1923 Tokyo earthquake took 140,000 lives, mostly in the ensuing fire storm. In 1976, perhaps 250,000 died in the earthquake in Tangshan, China. In 1988, 25,000 died almost immediately in the earthquake in Soviet Armenia.

Many, if not most, of the newspaper accounts surveyed the broad destruction and predicted it would take as many as 10 years for Kobe to rebuild and its economy to

recover [23] [25, p. 45]. In fact, less than 15 months later, in March, 1996, manufacturing in greater Kobe (Hyogo Prefecture) was at 98 percent of its pre-earthquake trend [1, p. 7]. Eighteen months after the quake, in July 1996, all department stores and 79 percent of shops had reopened. Department store sales were at 76 percent of pre-earthquake levels. [1, pp. 11-12] Though something less than half of the port facilities were rebuilt one year after the quake, import trade was fully recovered and export volume was at 85 percent of predisruption [1, pp.12-13]. There were still empty tracts of land in the inner city where the fires had raged, and some scattered construction still in progress. But all debris had been removed--a colossal undertaking [16]; lifeline utility services had been fully restored within three months—electric power in a few days or less; all roads and rail systems, other than the major expressways, had become operational within seven and five months, respectively; the Hanshin expressway, the major artery, was rebuilt in 21 months (although the collapsed portion, almost as embarrassing to authorities as the surrender to General MacArthur fifty years earlier, was pulverized and hauled away in 13 days [16, p.354]); and complete reconstruction of the port was celebrated after 26 months.

How does an economist explain this phenomenally rapid, but not quite complete, economic recovery?

The first principle is that output can be produced by variable combinations of resources. Even before the capital stock is fully rebuilt, a given output can be produced using less capital than previously but more labor, which works longer hours or more intensively, or more energy, which provides more heat to compensate for a building's gaping holes. Both of these occurred in Kobe during the recovery.

The second principle is that physical capital, though the most visible, is not the dominant economic resource in developed economies—human capital is. Destroy any amount of physical capital, but leave behind a critical number of knowledgeable human beings whose brains still house the culture and technology of a dynamic economy; the physical capital will then re-emerge like Topsy. Capital accumulation is especially easy the second time around because the primary goal is to duplicate an investment pattern, not design it from scratch. And, of course, horrendous as the fatalities were, 99.6 percent of the city's population survived. The world has seen such rapid recoveries before. Hiroshima, for one, was a bustling commercial metropolis just five years after the bomb. The German city of Aachen, reduced to rubble in World War II, did not even bother to remove the debris for some years. Instead, it moved major sections of the city and was booming again in the early 1950s.

Even though fatalities were relatively low, however, the population fell because not all of Kobe's human capital elected to remain in the Kobe area. Almost 100,000 residents migrated to other parts of Japan and have not returned [1, pp. 4-6]. These emigrants were six percent of Kobe's population. Many, if not most, clearly had marketable skills and, like most emigrants, were probably entrepreneurial. Their continued absence could prevent Kobe from reaching its predisaster trend output. They made a difference.

Any economy is normally in constant flux, responding to new resource availabilities, tastes, and technologies. In this light, the destruction of physical assets is a

form of accelerated depreciation which hastens the adoption of new varieties of investment. Thus a third principle is that the restored economy will tend not to be a replica of the predisaster one. In Kobe, for example, one major department store permanently altered its line of goods and the city government undertook to widen previously impassable streets.

A corollary to the rapid recoverability of modern economies that are also very large is that natural disasters tend not to perceptibly affect their total domestic output (or the general price level, which a disaster-induced reduction in output would tend to raise), even in the short run. The Kobe area's share of Japan's gross domestic product is about 1.5 percent, but in Japan's huge relative-price directed markets, resource substitutions outside the afflicted area quickly compensated for the losses. Port business moved to Osaka, Yokohama, Tokyo, and South Korea. Large manufacturing companies shifted output to plants in other locations.[1] The production of large and small manufacturers was replaced by that of competitors elsewhere. Although there is overwhelming evidence that Japan's markets are often tightly controlled, cartelized, and not easily penetrated by newcomers, markets clearly were fluid enough to make these adjustments. In fact, monopoly and cartelized industries, by nature, operate under conditions of excess physical capacity, which probably increased their ability to raise output on short notice. Additional excess capacity came from the general weakness of the Japanese economy since 1990, and even more so in Kobe, a region generally declining before the earthquake (which also to some extent explains delays in the rebuilding process as city planners seek to alter the city's infrastructure in order to attract new industries).

A second corollary to an economy's ability to recover quickly from shocks is that such an economy will minimize the damage--as a percentage of its total assets--it suffers in the first place. Kobe's \$100 billion damage bill is probably as much a reflection of its enormous wealth as its lack of earthquake preparedness. A better measure of damage is the loss of life in Kobe, which, as we have noted, does not approach that of urban earthquakes at other times and places. It is relevant, too, that the fatalities tended to occur in older, lower-income sections of the city, often in neighborhoods of prewar construction.

This brings us to our next economic principle, which is that wealthier is safer. In the words of Fred Cuny, the late disaster entrepreneur: "If the earthquake that hit San Salvador hit Southern California, it would rattle the china--not kill 1,500 people" [4]. Aaron Wildavsky, the late political scientist of the University of California, explains why this is so by interpreting safety as the product of a growing market economy [34]. Safety, defined broadly as protection against hazardous things and circumstances, appears, for example, as less dangerous machinery and other instruments of production, improved construction quality, more reliable automobile brakes and steering mechanisms, and more extensive and accessible means of travel and communication. In what is essentially a trial and error market process, individual buyers weigh the cost of each technically feasible increment of safety against its expected benefit. If the balance is favorable, they purchase it. If the new safety feature fulfills its promise, it is retained; otherwise, scrapped. Since the demand for safety rises with income, a nation's per-capita income is a good first approximation to the degree of safety it enjoys.

Government, of course, also plays a direct role in securing safety through the provision of public goods and regulatory measures. Wildavsky is highly critical of government's ability to weigh costs and benefits objectively. Indeed, government's basic nature illustrates yet another economic principle; namely, that it is a noncompetitive monopoly producer subject to political pressures and bureaucratic incentives. Moreover, the ballot box, its main source of feedback, is generally an infrequent, imprecise, and sometimes contradictory source of information. [33, chap.6] Still, we need government to provide at least the safety infrastructure, things that markets are not likely to supply: acceptably clean air and water, the sanitation system, immunization against disease, most roads and highways, and synchronization of building-code adoption [2]. It is significant that of the many buildings in Kobe, including the city's highest towers, that were built under a 1981 code, only one suffered more than minor damage. Japan clearly possesses an advanced, government-provided or assisted safety infrastructure.

Meanwhile, a rise in income will provide not only general safety, but at a high enough income, protection specific to disasters. Early in economic development, most disaster initiatives are public goods and will be undertaken, if at all, by government or charitable organizations. But eventually the private interest in protecting life and property from rare but catastrophic events materializes [17]. At the income threshold of private disaster protection or self-help, we see the emergence of emergency and risk management departments in commercial and other enterprises, the appearance of private disaster consultants, and the spread of disaster property insurance and self-insurance through private saving. All of these, with the exception of property insurance, have become major sources of individual self-protection in Japan. Private saving is perhaps the least recognized source of disaster self-help. Mark Skidmore, a Fulbright scholar in Japan last year, found persuasive empirical evidence that almost a third of Japan's very considerable private saving is earmarked to cover anticipated losses from natural disasters [29]. These self-help measures are exactly what one should expect in an affluent, disaster-prone society in which most property is privately owned. Roughly three-quarters of the losses in Kobe involved private property.

In the Wildavsky framework, Japan's economy incorporates a relatively high degree of built-in safety: its per capita income is 80 percent of that of the United States, the world's highest. That accomplishment is the product of a dynamic market economy supported by a government that has protected private property rights, contributed to economic and social stability, and provided public schooling and the safety infrastructure. That is the good news. The bad news is that Japan is far from reaching its *potential* income or safety, which could equal or exceed that of the United States. Japan's shortfall is caused by a vast array of government regulations and private practices that insulate its enterprises, large and small, from both domestic and foreign competition and thereby limit the economy's income and growth [8] [9] [12] [15] [24], its general level of safety, and its disaster resilience.

For example, many of Japan's heavy industries are pure cartels [31]. Its lifeline industries, including telecommunications, are either national or local monopolies, often lacking the more efficient organizational structure and advanced technology seen elsewhere in the world. Trucking, airlines, and coastal shipping are minutely regulated and

barred to uncertified entrants. Entry into retail and wholesale trade is tightly controlled and heavily biased toward small shops and big established firms. By first-world standards, Japan's banking, insurance, and capital markets are underdeveloped and handicapped by many constraints, among them restrictions on pricing services according to risk [10]. Barriers to foreign enterprise and capital—often informal—are, of course, common. Moreover, a third of Japan's very considerable savings is channeled through the postal saving system, where it is allocated by the Ministry of Finance on political rather than economic criteria [12]. Directly affecting Japan's disaster resilience are its building-height restrictions, which make no distinction between locations that vary in their earthquake vulnerability. (Charles Scawthorn, of EQE International, estimates that an optimal relocation of property in Tokyo so as to minimize earthquake vulnerability could reduce losses from a tremor by hundreds of billions of dollars [27].) Perhaps the clearest evidence that Japan has fallen short both of its growth and disaster-resilience potential is that bankruptcy and mass layoffs in declining industries are exceedingly rare. Bankruptcy, in Joseph Schumpeter's memorable phrase, is "creative destruction," capitalism's life force.

In a moment I will look at the direct involvement of government and the private sector in responding to the Kobe earthquake. But whatever one may regard as the optimal public and private roles, it seems unarguable that no one should settle for an economy whose manufacturing, communication, transportation, capital markets, distribution network, insurance markets, and overall income and technology are less than they can be. It would be a costly policy error to focus narrowly on the enhancement of public disaster management, ignoring the enormous amount of protection that sheer growth can provide—quite readily, I believe, in the case of Japan and other advanced, but overregulated, economies.

In evaluating the proactive roles of public and private responders, the unfettered market is a logical and well-defined standard of efficiency. Although direct market activity is certainly not feasible in every circumstance, including early phases of disaster relief, no sequence of nonmarket transactions can match the precision with which buyers and sellers in a price-directed competitive market signal their preferences and arrive at mutually satisfactory exchanges. Even when we cannot have this, we need to know exactly what we are missing and devise techniques for approaching it.

The earthquake struck a community, almost no member of which really believed it would happen. It had been a millennium since an event of comparable magnitude had occurred in the Kansai region [26, p.5]. Even businesses and agencies that had previously drawn up emergency plans were caught by surprise and were generally unable to implement them. Neither the local or central government was prepared [13]. Although natural disasters are usually local events for which local government has primary responsibility, Japan's central authorities know better than I the numerous ways in which they could have helped but did not. Merely supplying information about the extent of the disaster would have been enormously helpful. Tokyo, after all, with its power intact, had access to that resourceful American television network, CNN.

By and large, individuals, businesses, public and private agencies, lifeline companies, and before long, as many as a million volunteers [37, p.195], acted

spontaneously but without overall coordination and accountability. As in most disasters, most rescues were carried out by neighbors. As expected, most businesses, acting in their own interest, strove mightily to salvage what they could and maintain a semblance of the operations they knew more about than did anyone else. On Day 1 the Co-op grocery chain was able to open 97 of its 363 outlets while also delivering relief goods to the city's nine ward offices under a prior agreement [37, pp.142-3]. Their computer systems down, managers resorted to the paper and pencil bookkeeping they had practiced 20 years earlier. The Daiei department stores, guided by their Tokyo headquarters, immediately dispatched helicopters, trucks, and ferry boats in a massive resupply operation [37, pp. 136-7]. The IBM headquarters staff in Kawasaki established a "war" room from which they briefed their Hanshin dealers in emergency procedures and serviced a hot line for all their area customers. There were many bold, positive initiatives undertaken by private, public, and quasi-public entities.

By the end of the first day about 90,000 of the 300,000 homeless were housed in public schools, which are built to rigorous standards, or in churches or tents [37, p. 133] or with relatives and friends. By Day 2 most of the rest were accommodated, except for a significant number, mainly minorities, who remained in unprotected open areas, such as parking lots. By the end of the first week, government began constructing the first of 40,000 temporary housing units. For the most part, local government oversaw and coordinated the housing process.

Without piped water or backup water supplies, firefighters were limited in what they could do to contain the fires. Many joined the massive rescue operation. The power company was probably the most experienced in emergency response, and the system was largely functioning again within a day or two. Unfortunately, electric space heaters, on which flammable objects had fallen, created fires when the current was restored. Water was eventually trucked from many sources. Sanitation became a massive problem and was only gradually met with portable facilities on a site-by-site basis. Most egregious was the failure of the natural gas distributor, a privately owned utility, to shut off its main valve immediately. Although employees were on duty and promptly notified headquarters in Osaka of the quake, a company consensus decision to act did not come for six hours [32, p. 103]. Equally unfortunate was the prefectural government's failure to activate rescue units of the Self-Defense Forces, Japan's military, for 36 hours [32, p. 151] [37, pp. 62-67].

Offers of assistance poured in from all over Japan and the outside world. Almost certainly, there was little needed that was not available within the Kansai area. Nor is it likely that anyone not on the scene and without close contact with local officials, could have known what those unmet needs were. Nevertheless, the Kansai International Airport was soon swamped with foreign goods, medical personnel, and search dogs of various nationalities and breeds, all straining to travel the clogged highways to Kobe in the company of interpreters who, it was hoped, would miraculously find housing for them [14] [19] [20] [21] [22] [32, chap. 4] [37, pp. 206-9]. If the authorities were adequately prepared in the first place, most of the unsolicited aid from overseas and even much of it from elsewhere in Japan would have been seen as unnecessary. Under the circumstances, however, it all looked good, especially to the victims and the media, neither of whom had

responsibility for sorting it all out and delivering it. Into this maelstrom the Kobe authorities plunged, wanting instinctively to reject it all (as did the wise leaders of Los Angeles a year earlier when, following its earthquake, they quickly let it be known they wanted nothing, including advice, from outside California—except money.). But under pressure from the media and the foreign ministry in Tokyo, and after making bureaucratic-sounding excuses about doctors and dogs lacking proper licenses, Kobe yielded to the foreign assistance [36].

The resulting mismatches and incompatibilities between Japanese and foreign medical personnel and search teams were innumerable. A heavy burden of sorting donated goods also fell upon volunteers, many of whom felt that their time and effort were not well spent [14] [20]. The general problem in these outcomes is addressed by two more economic principles. One is economists' denial of the so-called physical fallacy [30, chap. 3]. This fallacy judges the value of a good or service by its physical properties, ignoring its packaging, location, time of availability, or other relevant characteristics, which, when taken account of, may double or triple its cost and final delivered price. An example would be Danish powdered milk, which came in huge containers and had to be repackaged into smaller units after making its tortuous way from Kansai Airport to Kobe and before being delivered to the needy. Relief workers, who had access to locally produced powdered milk well before the donated milk became available, did not view such "gifts" with enthusiasm or attach quite as much value to them as their donors likely did.

The other economic principle is that in most circumstances, in-kind gifts are of much less value to recipients than equal gifts of money [7]. In the absence of market prices or direct communication, donors or their agents can only guess what recipients want most; money, of course, enables recipients to buy what they please. The myth that survivors are too dazed or disoriented to make intelligent choices is just a myth, long since refuted by sociologists [5, pp. 7-8]. In-kind gifts are justified only when markets are not functioning (a rare occurrence in developed economies) or recipients are not able to access the market as speedily as the donor and the donor has reasonably good information about what recipients want.

One cannot blithely assume, moreover, that donors necessarily are motivated to satisfy recipients as recipients might satisfy themselves. Public and private charitable organizations are governed by their own fund-raising constraints, which color the kind and degree of aid they supply [3, chap. 7]. We have much documented evidence that the products of politically influential companies and sectors loom large in gifts to foreign as well as domestic disaster victims [18]. And on a more personal level, who has never succumbed to the impulse to clean out the attic for a humanitarian, tax-deductible cause?

Volunteers, meanwhile, maximize their effectiveness when they are coordinated by organizations, public or private. Student volunteers in Kobe tended to be constrained by class schedules; doctors, on occasion, failed to keep disaster-related commitments when personal business drew them away [32, p. 157].

A further hazard of in-kind charitable or volunteer activity is that it will compete with and harm still viable commercial enterprises, to the community's ultimate detriment [3, pp. 97-98]. I encountered only one apparent example of this in Kobe; private for-profit medical clinics complained that the Red Cross hospitals were providing relief services well past the time it was justified.

The Japanese government traditionally has offered only minimal disaster compensation in the form of immediate relief. Its commitment to provide 38,000 subsidized low-income housing units and 42,000 middle-income units for victims of the quake, though understandable, is a departure from that policy. If substantial compensation were to be expected in future disasters, it could, in some measure, encourage people to place themselves in harm's way more than they might otherwise do. This would be the "moral hazard" of policies; i.e., the principle of unintended perverse behavioral consequences. Such outcomes are more likely in economies less tightly regulated than Japan's, but could pose a problem if compensations continue and Japan undergoes serious deregulation.

Given that disaster preparedness and planned response spring naturally from private market activity, public disaster management will maximize its own effectiveness when it simultaneously promotes market forces. If Japan, for example, is truly serious about enhancing general communication capability following a disaster--any disaster, anywhere, any time--it will end the exclusive control over local exchanges now exercised by its telecommunications monopoly, NTT. This action will sharply reduce the cost of domestic calls, increase the quantity, and open the way to numerous technologies that bypass the local exchanges but are not now accessible. Similarly, removing the tight controls on Japan's distribution network will uncork myriad wholesale and retail alternatives, vastly reducing the cost and increasing the quantity and variety of goods available both pre- and post-disaster (Japan, too, can have the equivalent of Kmart, Wal-Mart, Target, Sam's Club, and Big Lots). Japan should also immediately formally recognize the several volunteer organizations that originated in the earthquake response and have continued to function since then on a national level. Without recognition, they cannot enter into contracts and they are not tax free. But there is no immediate prospect of this happening; the Ministry of Finance is loathe to forgo any source of revenues.

In this context, government should define its primary disaster role as overseer. As income and wealth grow, the private sector will take increasing responsibility for both anticipation and response, and government should be prepared to curtail its own managerial role and avoid competing with emerging private initiatives. Meanwhile, government should rely as much as possible on privatized contract services, including private disaster consultants, who can offer a far broader range of experience and specialization than civil servants are likely to command. Japan, finally, should avoid granting exclusive franchises to its lifeline producers, instead converting power lines, telephone lines, and gas lines into de facto common carriers. The use of these facilities, subject to periodic testing and review, should go to private competitors that meet the highest affordable standards of performance and safety.

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