Estimating economic losses in the Bay Area from a magnitude-6.9 earthquake

Data from the BLS Quarterly Census of Employment and Wages are used to analyze potential business and economic losses resulting from an earthquake on the Hayward Fault in northern California

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According to the U.S. Geological Survey, the Hayward Fault in northern California generates, on average, "a damaging earthquake every 150 years." The Hayward Fault is considered "the single most dangerous fault in the entire Bay Area because it is ready to pop and because nearly 2 million people live directly on top of it."[1] The last major earthquake on the Hayward Fault occurred 139 years ago, in 1868. It was known as the "Great San Francisco Earthquake" until 1906, when the city experienced a larger and more damaging earthquake on the San Andreas Fault. The Hayward Fault underlies Alameda County, a heavily populated urban area in northern California that is home to 41,000 employers, 682,000 employees, and a total quarterly payroll of $9.3 billion. In addition, Alameda County lies over approximately three-fourths of the length of the fault and therefore faces the greatest potential exposure to a damaging earthquake occurring on the fault. Geologists estimate that the fault has a 27-percent chance of experiencing a seismic event by 2032.

This article analyzes and maps employer data on employment and wages to assess potential business and economic losses from a magnitude-6.9 earthquake in northern California along the Hayward Fault. The article uses data from the BLS Quarterly Census of Employment and Wages (QCEW) to demonstrate how these data—when combined with seismic hazards information—can be used to assess potential business and economic losses from a major earthquake. (Such an approach could also be used to assess the damages from other natural disasters.) Labor market analysts from the California Employment Development Department overlaid employment data from the QCEW onto seismic hazard information provided by the California Geological Survey to produce maps and tabulations that correlate estimated shaking intensities with employment levels for the counties in the San Francisco Bay Area that lie along the Hayward Fault.

Methodology

Two sets of data were prepared for this analysis. First, the California Geological Survey produced a geographic file with Modified Mercalli Intensities (MMI) for the San Francisco Bay Area. The MMI scale gauges the level of intensity of the effects of an earthquake at different sites. Intensity differs from magnitude in that the effects of any one earthquake vary greatly from place to place, depending on a number of factors, including the area's proximity to the quake's epicenter, its population density, and the number of buildings and other structures located there. The MMI scale has twelve levels, ranging from barely noticeable (I) to catastrophic (XII). For this analysis, the file delineated the geography

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of the MMI zones from level VI (strong shaking, light damage) to level VIII and higher (severe shaking, moderate to heavy damage). Although the MMI is an ordinal scale, it correlates closely with measured shaking levels and is, by definition, a measure of damage.

The second data set was prepared by the California Employment Development Department (EDD) using the geocoded 2006 employer data from the Quarterly Census of Employment and Wages (QCEW), which collects information on establishments for unemployment insurance taxes purposes. The QCEW data are edited by staff from EDD and BLS to improve their usefulness for economic analysis and planning. The employment data used here include the major proximate Eastern San Francisco Bay Area counties, with particular emphasis on Alameda County, because it encompasses the most densely populated areas around the Hayward Fault, from Fremont in the southern part of the county to Berkeley in the north. EDD then produced industry tabulations that array potential exposures by industry and number of employers, employment, and quarterly wages within the MMI shaking intensity zones. These tabulations were then compared with countywide data.

Analysis

As mentioned previously, Alameda County has 41,000 employers, with 682,000 employees and a total quarterly payroll of $9.3 billion. Because the County encompasses roughly three-fourths of the length of the Hayward Fault, it is the most exposed county in the region, in terms of potential damage from earthquakes occurring on the fault.

Map 1 delineates the shaking intensity zones that would occur throughout the San Francisco Bay area in the event of a magnitude-6.9 earthquake. As is apparent, most of the areas with MMI levels of VIII or greater (shown in red) are in Alameda County. Map 2 shows the locations of employers in the area overlaid onto the shaking intensity zones. As can be seen from the map, a large number of employers are located in areas that are expected to experience the greatest shaking intensities.

The Bay Area. Table 1 shows total exposures in the nine counties in the San Francisco Bay Area that are in MMI zone VII and those in zone VIII or higher. As can be seen in the table, the two zones combined include 87,000 employers, 1.5 million jobs, and quarterly wages approaching $25 billion. In the wide area circumscribed by both zones, the employment and earnings exposures would fall, in descending order, primarily upon the counties of Alameda, Santa Clara, San Francisco, and Contra Costa. But the vast majority (87 to 89 percent) of the employment and earnings exposure in the MMI-VIII-or-higher shaking zone would fall in Alameda County.

Alameda County. Table 2 shows similar data for Alameda County only. The table shows that approximately 90 percent of the businesses, employees, and payrolls in Alameda County are located in the two most intense shaking zones on the map (MMI VII and MMI VIII or higher). Thus, these two zones include more than 600,000 employees who earn a total of $8.2 billion in quarterly wages. In addition, more than half of the businesses, employees, and payrolls in the county are located in the MMI-VIII-or-higher zone, the one characterized by severe shaking and moderate to heavy damage. These figures demonstrate that an interruption to business resulting from an magnitude-6.9 earthquake on the Hayward Fault would likely affect nearly all businesses and employees in Alameda County.

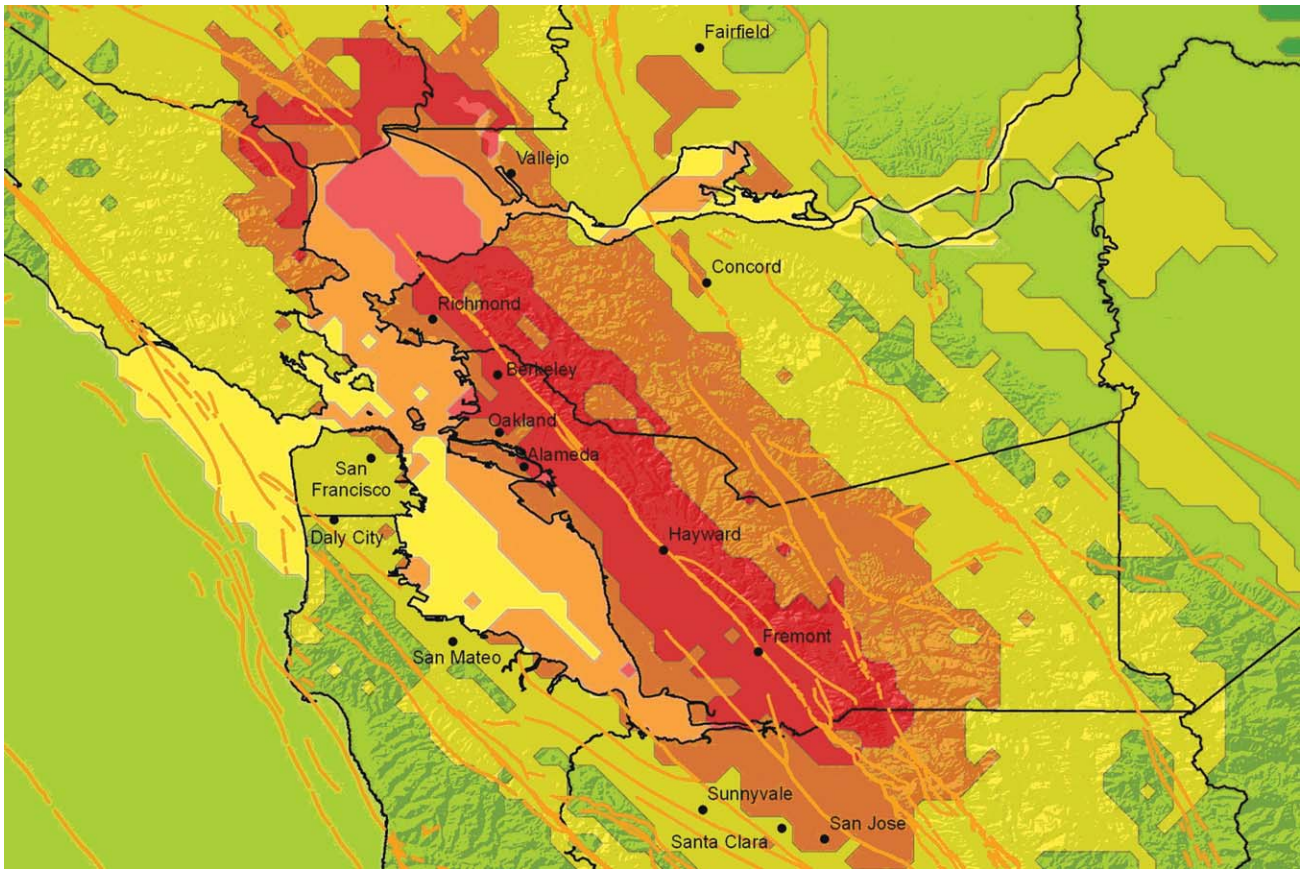
Industry analysis. The exposure to various industries ranges widely, but as chart 1 shows, it is particularly acute in health care and social assistance, educational services, manufacturing, and retail trade. The potential widespread economic consequences to San Francisco Bay Area employers and workers would most likely have a large impact on both the State and national economies.

Earthquake losses compared with Katrina losses

Because a similar methodology has been used to estimate business exposures resulting from Hurricane Katrina—that is, the use of geocoded employer data and disaster zones—it is instructive to compare these analyses. Hurricane Katrina struck the Gulf Coast in August 2005, with Louisiana and Mississippi experiencing the worst effects of the storm. Shortly after Katrina struck, BLS and EDD conducted analyses of businesses, employment, and quarterly wages in an attempt to understand the wide-ranging economic effects of this event. In this case, employment analysts from California, at the direction of BLS, were able to use Federal Emergency Management Agency (FEMA) identified damage areas (IDA), which had been mapped and converted into shape files. Analysts from California had undertaken this work because of their prior successful experience in mapping another regional disaster—the firestorms that struck southern California in October and November 2003.

Of course, flood losses are fundamentally different from earthquake losses in that flood waters inundate land and buildings. With earthquakes, the effect is differenti-

Map 1. **San Francisco Bay Area shaking intensity zones from a magnitude-6.9 earthquake on the Hayward Fault**

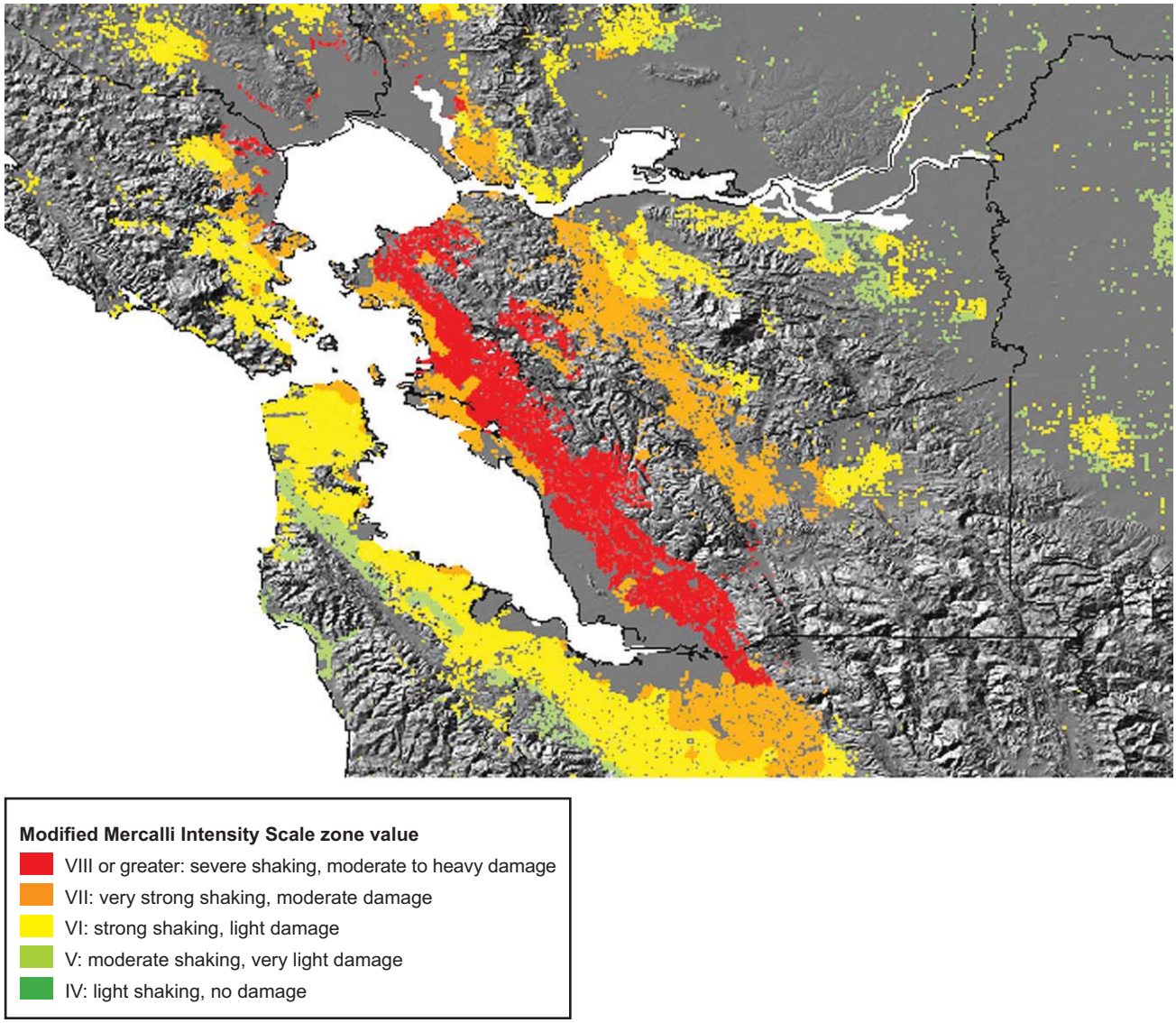


SOURCE: Modified Mercalli Intensity shape files from the California Geological Survey.

ated by the variety of building construction, site conditions, and ground motion levels at the site. Nonetheless, the example of Katrina illustrates that mapping expected hazard zones against business data can yield results that correspond closely with actual employment losses. This analysis shows that Hurricane Katrina had a major impact on the economies of Louisiana and Mississippi.

Losses in MMI zones VII and VIII or higher that result from a magnitude-6.9 earthquake on the Hayward Fault were compared with losses from Hurricane Katrina in the FEMA IDAs plus an additional one-half mile encompassing the FEMA IDAs. (See tables 2 and 3.) Although the Katrina exposures in Louisiana were extensive, the exposures in Alameda County from a magnitude-6.9 earthquake on the Hayward Fault would be much greater—20 percent more businesses, 22 percent more employees, and 74 percent more in payroll earnings. Thus, an earthquake of this magnitude in the San Francisco Bay Area could

Map 2. **Employers mapped by shaking intensity in the San Francisco Bay Area from a magnitude-6.9 earth quake on the Hayward Fault**



SOURCE: Geocoded data on employers from the Bureau of Labor Statistics Quarterly Census of Employment and Wages combined with Modified Mercalli Intensity shape files from the California Geological Survey.

have an even greater impact on businesses, employees, and payrolls in the area than Hurricane Katrina had in Louisiana and Mississippi.

Limitations

This analysis of business exposures due to earthquakes has certain limitations. The Modified Mercalli Index zones circumscribe areas where damage levels are predominantly light to heavy. In fact, not all businesses will sustain damage that will curtail their activities and some businesses that lose capability will quickly regroup and return to production. Thus, an assumption that certain MMI levels will lead to widespread business interruption may overstate the actual interruption or losses that will occur. However, the actual effects of a magnitude-6.9 earthquake also could be greater than those projected by an MMI shape file.

In addition, estimates of direct damage to a region's

Table 1. Exposure from a magnitude-6.9 earthquake along the Hayward Fault for nine San Francisco Bay Area counties

County	MMI VIII+ Severe shaking, moderate to heavy damage			MMI VII Very strong shaking, moderate damage		
	Employers	Employment	Quarterly wages	Employers	Employment	Quarterly wages
Total	30,533	458,712	$5,782,138,134	56,507	1,060,168	$18,995,839,013
Alameda	25,753	400,462	5,141,738,560	11,567	210,870	3,112,142,678
Contra Costa	3,392	36,606	340,548,652	11,936	180,576	2,609,854,090
Marin	154	1,807	21,803,937	2,280	29,371	416,044,149
Napa	56	446	4,189,187	618	11,423	136,324,614
San Francisco	([1])	([1])	([1])	12,220	239,022	4,959,257,643
San Mateo	([1])	([1])	([1])	753	24,249	653,217,259
Santa Clara	1,084	18,357	263,495,223	15,263	337,954	6,836,033,375
Solano	5	21	129,180	1,605	20,314	185,098,827
Sonoma	89	1,013	10,233,395	265	6,389	87,866,378

[1] No areas of San Francisco County or San Mateo County are expected to experience shaking intensities of level MMI VIII or greater.

NOTE: Data are from the Bureau of Labor Statistics Quarterly Census of Employment and Wages, third quarter, 2006

Table 2. Exposure from a magnitude-6.9 earthquake along the Hayward Fault, 2006

Alameda County		Shaking intensity areas		
Item	County totals	MMI VIII+	MMI VII	Combined MMI VII-VIII+
Employers	40,851	25,753	11,567	37,320
Employment	681,821	400,462	210,870	611,391
Quarterly wages (in billions)	$9.3	$5.1	$3.1	$8.2

NOTE: Data are from the Bureau of Labor Statistics Quarterly Census of Employment and Wages, third quarter, 2006.

Table 3. Estimated business exposures and employment losses from Hurricane Katrina in FEMA Identified Damage Areas, 2004

Item	FEMA Identified Damage Areas (IDA)	FEMA IDA + 0.5 mile	Measured employment losses, 2004–05
Employers	18,997	31,133	...
Employment	316,063	499,650	353,116
Quarterly wages (in billions)	$3	$4.7	...

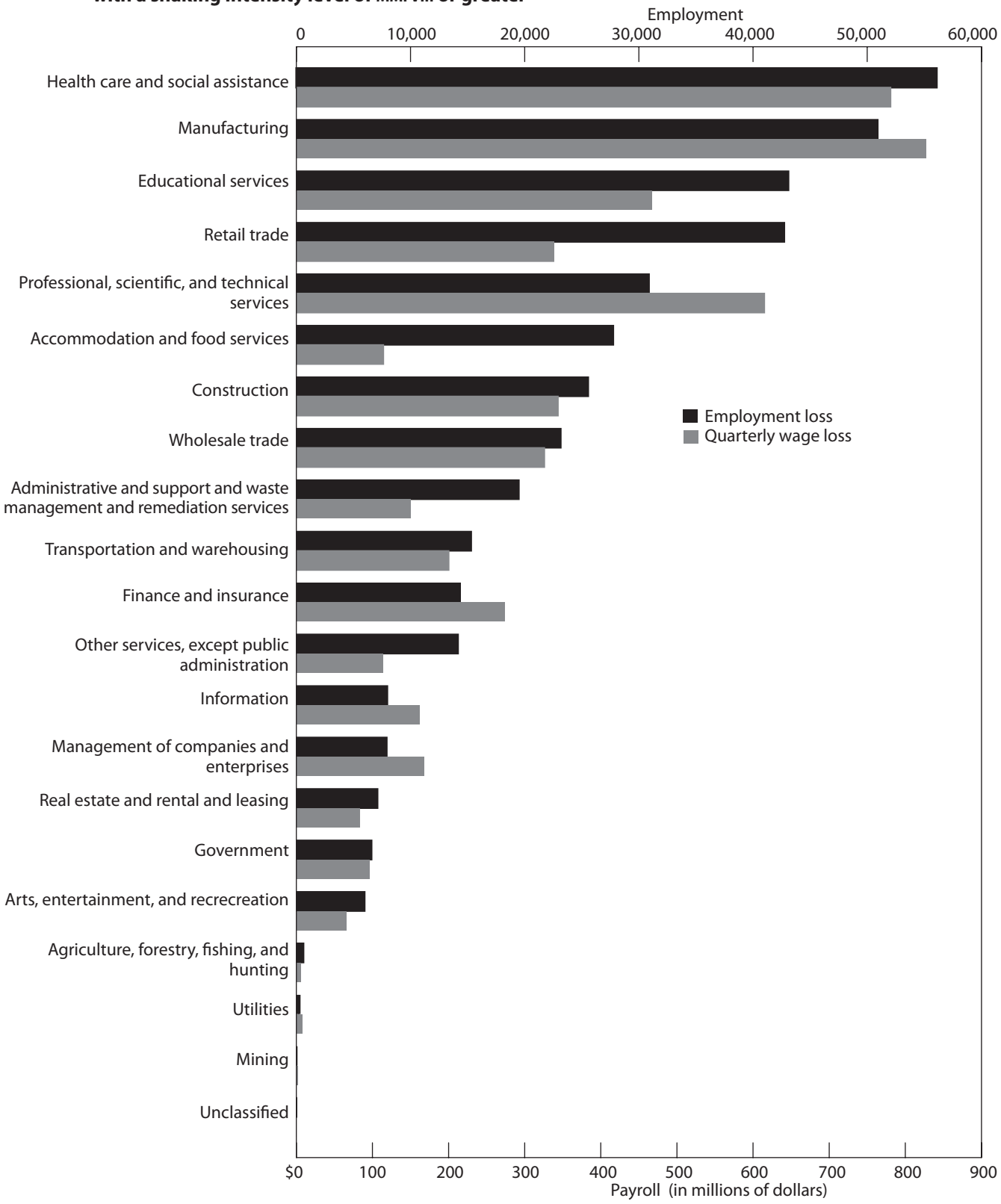
NOTE: Data are from the Bureau of Labor Statistics Quarterly Census of Employment and Wages, fourth quarter, 2004.

businesses understate the interactional effects upon businesses outside the damage areas that are customers or suppliers of businesses inside the damaged areas. Some businesses locate in regions in order to be physically closer to their customers and suppliers. If this relationship is interrupted by an earthquake, both customers and suppliers could be severely affected or even put out of business. Therefore, there may be greater (multiplier) losses inside and outside the region than would be observed in the damage areas.

By using geocoded employment data and shape files generated by earthquake shake modeling, this analysis concludes that a magnitude-6.9 earthquake on the Hayward Fault could have wide-ranging effects on businesses, jobs, and payrolls in the San Francisco Bay Area. Comparative analysis suggests that because of the large area of damaging earthquake shaking, these exposures could exceed those that occurred as a result of Hurricane Katrina. Large employment and payroll losses could occur in a wide range of industries, particularly health care and social assistance, manufacturing, educational services, and retail trade. Actual losses would depend on a number of factors that could result in greater or lesser exposure to businesses in the region.

One way to improve these estimates is to evaluate historical loss information for an earthquake in a comparable urban area. The magnitude 6.7 Northridge Earthquake that occurred on January 17, 1994, generated widespread damage and losses to buildings and businesses throughout Los Angeles County. As a result, data on insured losses were extensively collected. This information can be compared with

Chart 1. Potential employment exposures in Alameda County from a Hayward Fault magnitude-6.9 earthquake with a shaking intensity level of MMI VIII or greater



geocoded data on businesses to generate an assessment based on an actual—rather than a postulated—event with detailed data on insured losses and measures of employment and wages. This information might help calibrate the estimates of potential business interruption losses from a magnitude-6.9 earthquake in northern California. The authors are evaluating geocoded employment data against shape files of the 1994 Northridge Earthquake, as well as other information such as building loss data, that might assist the process of refining these estimates. The authors also are working to identify other information sets and collaborative partners that can assist in refining the method for assessing economic losses from a magnitude-6.9 earthquake on the Hayward Fault. □

Note

[1] *A Virtual Tour of the Hayward Fault* (U.S. Geological Survey), Mar. 9, 2006, available on the Internet at **www.usgs.gov/newsroom/article.asp?ID=1452.**