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**BUSINESSES AND THE 1994 NORTHRIDGE  
EARTHQUAKE: AN ANALYSIS OF  
PRE- AND POST-DISASTER PREPAREDNESS**

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**Businesses and the 1994 Northridge Earthquake:  
An Analysis of Pre- and Post-Disaster Preparedness**

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\*Names are listed in alphabetical order, contribution to the paper was equal.

## INTRODUCTION

While a great number of studies in the field of disaster research have focused on the preparedness activities of individuals, households, and public sector organizations, few empirical analyses of business disaster preparedness have been conducted. In his exhaustive review of the disaster literature, Drabek (1986) noted "the entire matter of disaster planning within the private sector merits extensive study so as to permit documentation of the range of variation and its determinants"(30). Although the last ten years have seen an increasing interest in the area of businesses and disaster, the recent proliferation of publications has focused on how to plan for and reduce disaster-related business disruption (Alesch et al. 1993). We still know very little about the extent of actual business disaster preparedness and its determinants.

The lack of empirical research on business preparedness is surprising given that the disaster literature is replete with descriptions of disaster related commercial disruption. For instance, the Xenia, Ohio, tornado of 1974 destroyed 155 commercial and 4 industrial businesses, and severely impacted 100 other firms (Francaviglia 1978). The 1989 Loma Prieta earthquake destroyed or extensively damaged up to 60 percent of the Santa Cruz downtown businesses (Disaster Research Center 1993). More recently, due to the 1994 Northridge earthquake, approximately 50,000 businesses applied for U.S. Small Business Administration loans to cover earthquake-related losses. In her analysis of business impacts following the 1994 Northridge earthquake, Tierney (1995) found approximately 56 percent of the Los Angeles and Santa Monica businesses surveyed suffered some type of direct physical damage.

These examples clearly show that disasters can cause extensive commercial disruption. This disruption, in turn, can have severe consequences not only for the businesses involved but also the

individuals, families, and communities that depend upon them. For example, Nigg (1995) has suggested that businesses are central to communities because they provide goods, services, and employment opportunities for local residents. The longer businesses are forced to close the greater the inconvenience for customers and the financial strain for individuals and families whose members are employed by those firms. Other common negative impacts include the potential for permanent loss of important and/or large employers, loss of property and sales tax revenues to affected communities, and the need to undertake complicated and time-consuming redevelopment projects (Tierney 1994).

Disaster preparedness is one means of reducing business damage, business interruption, and other negative disaster impacts. Research at the individual, household, and community levels suggests that pre-disaster preparedness efforts result in a more effective response to disasters (Mileti, Drabek, and Haas 1975; Perry 1979; Perry and Greene 1982). As conceptualized here, disaster preparedness consists of activities that have the potential for saving lives, containing property damage, and generally reducing the disruption that disasters can cause. Preparedness measures that businesses can undertake include such activities as developing disaster response plans, training employees in how to respond when a disaster occurs, stockpiling emergency supplies, and making arrangements to relocate business operations should the business property sustain severe damage. Like households and communities, businesses that invest in preparedness should be better able to avoid severe losses and disruption in the event of a disaster.

To better understand the extent to which businesses prepare for disasters and which firms are more likely to do so, this paper focuses on the preparedness behaviors of businesses in Greater Los Angeles, the region affected by the Northridge earthquake, the most costly disaster to occur in

the U.S. to date. As a result of that quake, 57 people died and over 10,000 were injured; direct losses due to the earthquake are currently estimated at \$30 billion (Tierney 1995). The paper addresses the following research questions: (1) To what extent did businesses prepare for disaster both before and after the Northridge earthquake? (2) What types of preparedness activities are businesses likely to engage in? (3) And what factors constrain or facilitate preparedness among private firms? Drawing upon the existing literature on business disaster preparedness, we develop and test a model of pre- and post-disaster preparedness using path-analytic techniques.

## **LITERATURE REVIEW**

With the exception of some recent studies (Dahlhamer and D'Souza forthcoming; Drabek 1994b), research on business disaster preparedness has been limited by small sample sizes (Barlow 1993; Mileti et al. 1993), less advanced, non-multivariate analytic techniques (Drabek 1991; Mileti et al. 1993), and a focus on specific industries, rather than on the entire range of business enterprises (Drabek 1991; Gabor 1981; Quarantelli et al. 1979). These factors clearly limit the generalizability of the findings. Despite its limitations, the literature does provide some theoretical and empirical basis for developing a model of pre- and post-disaster business preparedness. For example, previous research has identified a number of business characteristics that appear to be related to disaster preparedness. Firm characteristics associated with the adoption of preparedness measures include the age of the business (Drabek 1991; Quarantelli et al. 1979), the number of full-time employees (Dahlhamer and D'Souza forthcoming; Drabek 1994a, 1991; Quarantelli et al. 1979), ownership patterns (own/lease) (Dahlhamer and D'Souza forthcoming), whether the business is an individual firm or franchise (Drabek 1991, 1994a, 1994b, 1995; Quarantelli et al. 1979), and the economic sector

to which the business belongs (Dahlhamer and D'Souza forthcoming; Drabek 1991, 1995; Mileti et al. 1993). Additionally, researchers have found that, as is generally the case with households and communities, previous disaster experience increases preparedness among private firms (Banerjee and Gillespie 1994; Dahlhamer and D'Souza forthcoming; Drabek 1994a, 1994b; Mileti et al. 1993).

### **Size**

Size, generally defined as the number of employees, is the factor that is most frequently cited as having a positive impact on disaster preparedness. For example, Quarantelli et al. (1979), focusing on chemical companies in 18 U.S. communities, found smaller firms to be much less likely than larger ones to engage in preparedness activities. For the most part, small independent chemical companies did not consider themselves a serious disaster threat to the local community, and consequently they downplayed the necessity of engaging in internal preparedness activities or planning with other community groups.

More recently, Dahlhamer and D'Souza (forthcoming) found size to be positively related to preparedness among two samples of U.S. firms. Large businesses in Des Moines/Polk County, Iowa (Des Moines), and Memphis/Shelby County, Tennessee (Memphis), were more likely to engage in preparedness activities than their smaller counterparts. Size was the strongest predictor of preparedness among businesses in both communities.

Finally, focusing on 65 tourist-oriented firms selected from communities with progressive local government disaster programs, Drabek (1991, 1994a, 1994b) found size to be a significant predictor of disaster evacuation planning. In later multivariate analyses of 180 tourist-oriented firms, Drabek again found size to be a significant predictor of evacuation planning with larger firms more likely than smaller firms to engage in preparedness activities.

## **Age**

Age of the business has also been included in analyses of business disaster preparedness, but the impact of age is less clear than that of size. For example, Quarantelli and associates (1979:15) found that newer chemical companies, usually built in industrial parks, were more likely to engage in "more intensive and extensive disaster planning" than older chemical firms. Drabek (1991) found years in operation to be related to evacuation planning among his sample of 65 tourist-oriented firms, with more extensive planning taking place in businesses that had been in existence for six or more years. Age, however, had little impact on preparedness beyond this threshold of six years. Nor did age significantly influence evacuation planning in Drabek's (1994b) larger study of 180 firms. Similarly, Banerjee and Gillespie (1994) found age to have a significant, positive influence on preparedness among 80 disaster response firms in bivariate analyses. However, when multivariate analyses were conducted, the effect of age on preparedness disappeared.

## **Ownership Patterns**

Whether the business is an individual firm or part of a franchise or chain has also been shown to influence preparedness. Quarantelli and colleagues (1979) found that larger national chemical companies with multiple sites engaged in more extensive planning for disasters than locally based, individual firms. This was largely due to corporate mandates and policy directives that instructed national companies to develop chemical disaster preparedness programs. This finding is consistent with Drabek's more recent research on tourist-oriented firms (1991, 1994a, 1994b, 1995), which found that firms that are part of larger national chains were more likely to engage in evacuation planning activities, largely due to corporate mandates.

## **Property Ownership**

Recent research suggests that ownership of the property in which the business is located may also influence business disaster preparedness. Dahlhamer and D'Souza (forthcoming) discovered that firms that owned rather than leased their business properties were more likely to engage in preparedness activities. This result was consistent for both their Memphis and Des Moines samples, although ownership of property was a stronger predictor of preparedness for the sample of Memphis firms. They explained this relationship by noting that owners of buildings, by virtue of the greater control they have over the property, have a greater capacity to engage in preparedness activities. For example, an owner could have an engineer structurally assess the building housing the business, an activity that a lessee would not be likely to undertake. Compared with renters, owners may also feel (justifiably) that they have more assets at risk and may thus be more concerned about reducing disaster losses.

## **Financial Condition**

Although intuitively it would seem that the financial condition of a business would affect its ability to prepare for disaster, surprisingly, very few studies have examined this relationship. Quarantelli and associates (1979) did find that wealthier chemical companies, which also tended to be larger and more safety-conscious, were more likely to engage in planning than smaller local firms which could not afford to do so. Consistent with these findings, Alesch and his associates (1993) noted that small firms tend to be particularly vulnerable to disaster impacts and losses since they tend to have few cash reserves and cannot afford to engage in various preparedness and mitigation measures.



## **Type of Business**

Previous research also suggests that the nature of the business enterprise is related to disaster preparedness. In their Memphis sample Dahlhamer and D'Souza (forthcoming) found businesses in the finance, insurance, and real estate (FIRE) sector to be significantly more likely to engage in preparedness activities than firms in the "other" sector (agriculture, forestry, fishing, mining, transportation, communications, and utilities). Among his sample of 65 tourist-oriented firms, Drabek (1991) found that lodging establishments were more likely to engage in evacuation planning than restaurant, entertainment, and travel firms. Finally, Mileti and associates (1993) in a study of 54 San Francisco Bay Area firms found that health, safety, and welfare organizations that had staff with preparedness activities included as part of their jobs and executives with higher levels of earthquake risk perception were more likely to engage in earthquake preparedness activities.

## **Disaster Experience**

Previous disaster experience has consistently been shown to affect business disaster preparedness. Dahlhamer and D'Souza (forthcoming) found that businesses with previous disaster experience in both their Des Moines and Memphis samples were more likely to engage in preparedness activities. Drabek (1994a, 1994b) also found that tourist-oriented firms with previous disaster experience were more likely to engage in disaster evacuation planning than firms with little or no experience. Finally, Banerjee and Gillespie (1994) found previous disaster experience to be positively related to preparedness among 80 U.S. disaster response organizations. Studies suggest that the impact of experience is cumulative; the more a business is subject to repeated disasters, the more likely that businesses is to take preparedness seriously.

At the same time, not every neighborhood, household, or business that goes through a disaster experiences the same degree of loss and disruption. In some cases, disaster impacts may not be serious enough to stimulate additional preparedness. The relationship between the severity of disaster impact and the propensity to prepare for future disasters has not been studied to any great degree; however, work by Mileti et al. (1975) suggests that high levels of damage influence awareness of the need for disaster preparedness. In this paper, we attempt to take into account not only the extent of previous experience in other disasters but also the severity of the damage and disruption firms experienced in the Northridge earthquake. These direct and indirect impacts include physical damage to the business property and its contents, loss of utilities, and forced closure of the business.

## **METHODOLOGY**

Building on findings from previous research, we developed a model explaining pre- and post-disaster preparedness (see Figure 1). The variables employed in the analyses are presented in Table 2. The exogenous or independent variables include age of business, number of full-time employees, whether the business property was owned or leased, type of ownership (franchise or individual firm), types of business (wholesale/retail, business and professional services, manufacturing/construction, finance/insurance/real estate), previous disaster experience, and the financial condition of the business prior to the Northridge earthquake. Endogenous variables in the model include the level of pre-earthquake preparedness, earthquake related physical damage, lifeline service interruption (e.g., loss of electricity, phones, water, and sewer), and the length of business was lifeline service interruption (e.g., loss of electricity, phones, water, and sewer), and the number of days the business was closed or inactive as a result of the earthquake.

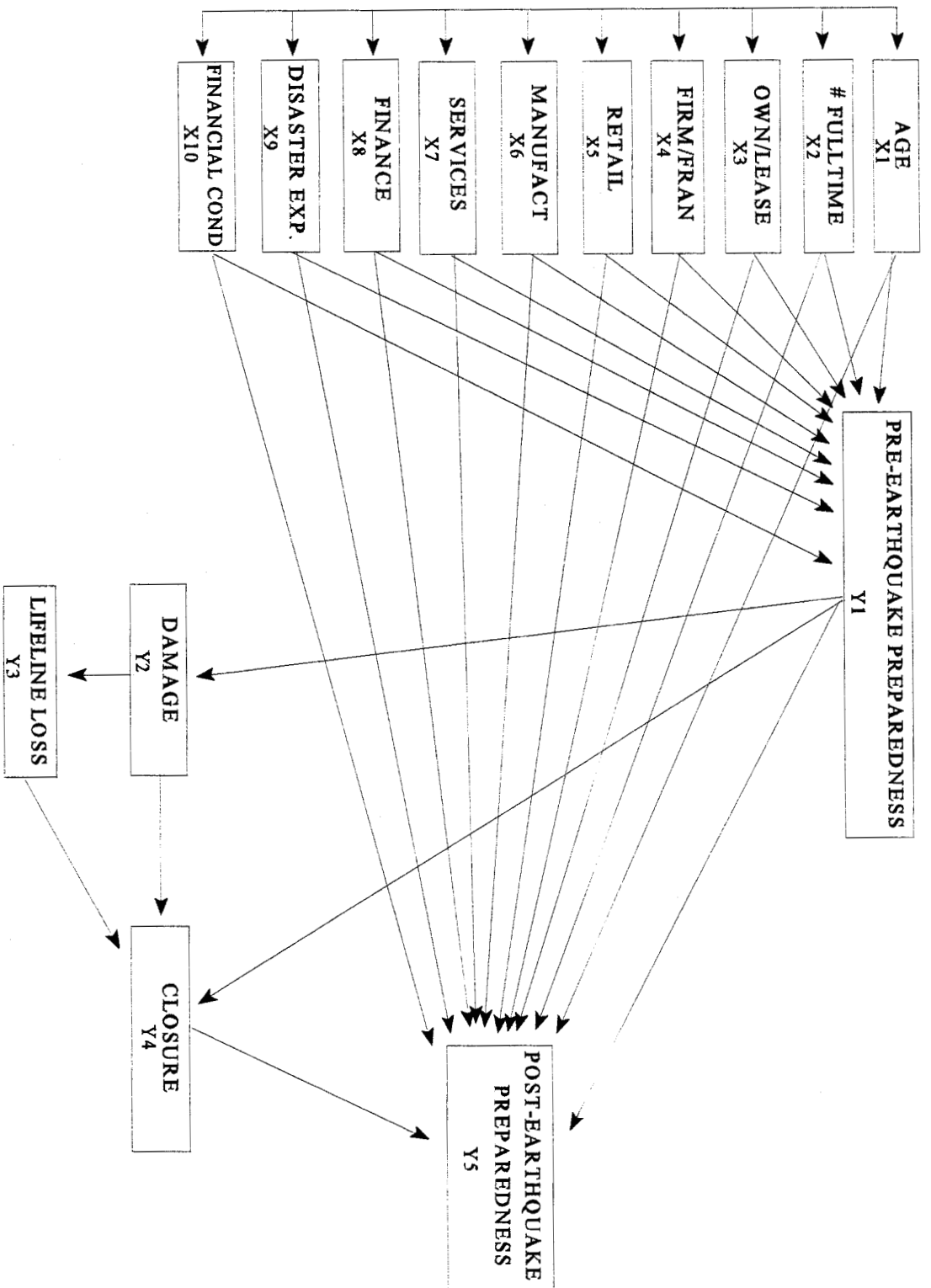


Figure 1: Proposed model of pre- and post-earthquake preparedness

Table 1. Variable definitions, (NAMES), and measurements

<u>Variables</u>	<u>Coding Scheme</u>
<i>Exogenous</i>	
Age of Business (AGE)	Continuous
log Number of full-time employees (#FULLTIME)	Continuous
Own or Lease (OWN/LEASE)	0=Lease 1=Own
Firm or Franchise (FIRM/FRAN)	0=Franchise 1=Individual firm
Wholesale/Retail (RETAIL)	0=Other 1=Wholesale/retail
Services (SERVICES)	0=Other 1=Services
Manufacturing/ Construction (MANUFACT)	0=Other 1=Manufacturing/construction
Finance/Insurance/ Real Estate (FINANCE)	0=Other 1=Finance/Insurance/Real Estate
Disaster Experience (DISASTER EXP)	0=No 1=Yes
Financial Condition (FINANCIAL COND)	1= In financial trouble; marginal 2= Not in financial trouble/not doing well 3= Good financial condition 4= Excellent financial condition
<i>Endogenous</i>	
Physical damage to property and contents (DAMAGE)	0=No physical damage 7=Seven different mentions of physical damage
Lifeline loss (LIFELINE LOSS)	0=Did not lose a single lifeline 4=Lost four lifelines (electric, phones, water, and sewer)
Business closure in days (sq. root) (CLOSURE)	Continuous
Pre-Disaster Preparedness (PRE-EARTHQUAKE PREPAREDNESS)	Index of 16 preparedness items
Post-Disaster Preparedness (POST-EARTHQUAKE PREPAREDNESS)	Index of 16 preparedness items

Post-earthquake preparedness, or the number of preparedness measures subsequently undertaking by businesses, is the dependent variable in the model.

A survey on the impact of the Northridge earthquake was mailed to 4,752 Los Angeles and Santa Monica businesses in the Spring of 1995. Businesses were selected using a three-stage stratified sampling design, with shaking intensity and type and size of business employed as stratifying variables. In the first stage of the design, businesses from Los Angeles and Santa Monica were aggregated into high (Mercalli XIII and IV) and low (Mercalli VI and VII) shaking intensity zip codes. In the next stage, businesses in the high and low Mercalli zip codes were aggregated into five economic sectors: wholesale and retail; manufacturing, construction, and contracting; business and professional services; finance, insurance, and real estate; and "other" businesses, which included businesses involved in agriculture, forestry, and fishing, mining, transportation, communications, and utilities. The final stage of the design involved the random selection of both small (fewer than 20 employees) and large (twenty or more employees) firms in each of the five industrial sectors identified above.

The data were collected using a modified version of Dillman's (1978) "total design method." This approach is widely used in mail survey research and consists of a series of mailings and telephone calls. The initial mailings were followed up by telephone calls to business owners after a reasonable period of time for questionnaire completion had passed. The final number of completed questionnaires was 1,110 resulting in a 23% response rate.

## RESULTS

Survey respondents were asked to indicate which of 16 preparedness measures had been undertaken at their businesses prior to the 1994 earthquake, since the earthquake, and both before and after the event. The activities included various forms of planning and training, efforts to modify the business property and its contents to make them more earthquake-resistant, and obtaining resources such as first aid kits and electrical generators for emergency power, that would improve the capacity of the business to handle disaster related problems. Table 2 indicates the percentage of businesses that undertook each of 16 different preparedness activities in those three time frames.<sup>1</sup> The mean number of preparedness activities businesses undertook before the earthquake was 3.9; that average rose slightly to 4.0 after the event. In general, businesses participated in approximately 25 percent of the 16 preparedness activities listed in the survey. The most popular preparedness activities undertaken before the earthquake included obtaining first aid supplies (60.5%), learning first aid (48.7%), attending meetings or obtaining earthquake preparedness information (38.8), storing water (35.8%), and talking to employees about earthquake preparedness (35.3%). After the earthquake, the preparedness activities that the greatest percentage of businesses performed were talking to employees about earthquake preparedness (51.0%), bracing shelves and equipment (48.4%), and attending meetings or obtaining earthquake preparedness information (44.4%). The preparedness activities that the greatest percentage of businesses performed both before and after the earthquake were attending

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<sup>1</sup>Businesses that reported undertaking preparedness activities both "before and after" were included in each of the pre- and post-measures of preparedness.

Table 2: Pre- and Post-Earthquake Preparedness Measures Performed by Los Angeles and Santa Monica Businesses

	%Did Before	%Did After	%Did Before & After
Attended meetings/ received info.	38.8	44.4	19.1
Talked to employees about preparedness	35.3	51.0	18.4
Purchased EQ insurance	18.2	8.3	3.5
Purchased business interruption insurance	24.3	8.4	3.2
Stored fuel or batteries	28.9	32.6	11.5
Learned first aid	48.7	21.6	10.8
Obtained first aid supplies	60.5	33.5	15.0
Developed business emergency plan	29.1	30.5	9.7
Developed business disaster recovery	13.5	16.0	3.9
Conducted EQ drills	16.7	19.0	7.3
Involved in EQ preparedness or response training	18.2	19.5	7.2
Arranged to move business to other location	5.2	8.1	1.8
Obtained generator	13.1	7.2	2.4
Braced shelves & equipment	25.8	48.4	9.1
Stored water	35.8	32.3	12.3
Assessment of building	13.7	33.9	6.3

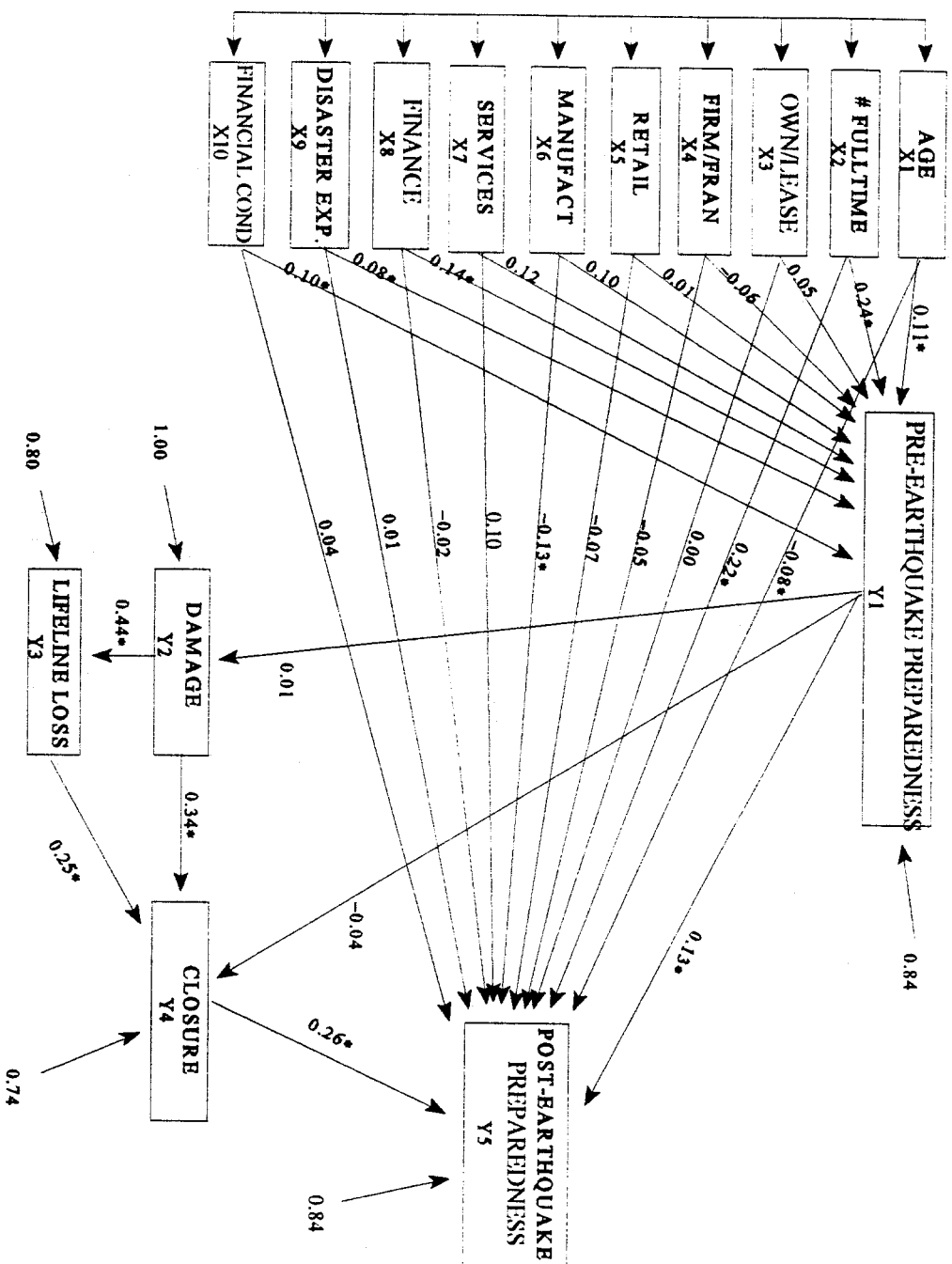
meetings or obtaining earthquake preparedness information (19.1%), talking to employees about preparedness (18.4%), and obtaining first aid supplies (15.0%).

Overall, these preparedness figures are low but consistent with other findings. For example, Dahlhamer and D'Souza (forthcoming) found that nearly half of the businesses in their Memphis sample had engaged in three or fewer preparedness activities (out of 17), while approximately half of the firms in the Des Moines sample had performed only a single activity (out of 13). Drabek (1994a) also noted that less than one third of the 180 tourist firms he sampled had satisfactory levels of preparedness. Finally, Mileti and associates (1993) assert that less than half of the 54 San Francisco Bay Area businesses they interviewed had engaged in any planning, storing of supplies, emergency drills or training, and creation or maintenance of emergency plans.

Some evidence of the way the earthquake's physical impacts affected preparedness behaviors of businesses can be seen in Table 2. For example, while bracing shelves and equipment was performed by only 25.8 percent of the businesses before the earthquake, this figure increased to 48.4 percent after the quake. In addition, only 13.7 percent of the businesses had their buildings assessed for earthquake resistance before the earthquake while 33.9 percent of the businesses engaged in this activity after the earthquake. Of all preparedness activities, these two showed the largest increase after the earthquake.

To test the proposed model of pre- and post-earthquake preparedness depicted in Figure 1, path analytic techniques were employed. Using a correlation matrix, LISREL8 (Joreskog and Sorbom 1993) was utilized to estimate, test, and modify the initial model. However, prior to model estimation, the number of full-time employees, the age of business, and the business closure variables were found to be non-normally distributed. Three outliers were removed from the age





**Figure 2:** Initial pre- and post-earthquake preparedness model  
 $(\chi^2=71.57$   $p<0.01$   $33$   $df$ ,  $RMSEA=0.045$   $p=0.71)$   
 NOTE: \*  $p<0.05$

Table 3: Direct, Indirect, Total Effects, and (Standard Errors) for the Initial Model of Pre- and Post Earthquake Preparedness

		PRE-EQ PREP	PHYS. DAMAGE	LIFELINE LOSS	CLOSURE	POST-EQ PREP
<i>Exogeneous Variables</i>						
AGE	Direct	0.11* (0.04)	---	---	---	-0.08* (0.04)
	Indirect	---	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.01* (0.01)
	Total	0.11* (0.04)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	-0.07 (0.04)
# FULLTIME		0.24* (0.05)	---	---	---	0.22* (0.05)
		---	0.00 (0.01)	0.00 (0.00)	-0.01 (0.01)	0.03* (0.01)
		0.24* (0.05)	0.00 (0.01)	0.00 (0.00)	-0.01 (0.01)	0.25* (0.05)
OWN/LEASE		0.05 (0.04)	---	---	---	0.00 (0.04)
		---	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.01 (0.01)
		0.05 (0.04)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.01 (0.04)
FIRM/FRAN		-0.06 (0.04)	---	---	---	-0.05 (0.04)
		---	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	-0.01 (0.01)
		-0.06 (0.04)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	-0.06 (0.04)
RETAIL		0.01 (0.06)	---	---	---	-0.07 (0.06)
		---	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.01)
		0.01 (0.06)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	-0.07 (0.06)
MANUFACT		0.10 (0.06)	---	---	---	-0.13* (0.06)
		---	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.01 (0.01)
		0.10 (0.06)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	-0.12* (0.06)
SERVICES		0.12 (0.07)	---	---	---	0.10 (0.07)
		---	0.00 (0.01)	0.00 (0.00)	0.00 (0.01)	0.02 (0.01)
		0.12 (0.07)	0.00 (0.01)	0.00 (0.00)	0.00 (0.01)	0.11 (0.07)
FINANCE		0.14* (0.05)	---	---	---	-0.02 (0.05)
		---	0.00 (0.01)	0.00 (0.00)	-0.01 (0.01)	0.02* (0.01)
		0.14* (0.05)	0.00 (0.01)	0.00 (0.00)	-0.01 (0.01)	0.00 (0.05)
DIS EXP.		0.08* (0.04)	---	---	---	0.01 (0.04)
		---	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.01 (0.01)
		0.08* (0.04)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.02 (0.04)
FINANCIAL COND.		0.10* (0.04)	---	---	---	0.04 (0.04)
		---	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.01 (0.01)
		0.10* (0.04)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.05 (0.04)
<i>Endogenous Variables</i>						
PRE-EQ PREP		---	0.01 (0.04)	---	-0.04 (0.04)	0.13* (0.04)
		---	---	0.00 (0.02)	0.00 (0.02)	-0.01 (0.01)
		---	0.01 (0.04)	0.00 (0.02)	-0.04 (0.04)	0.12* (0.04)
PHYS. DAMAGE		---	---	0.44* (0.04)	0.34* (0.04)	---
		---	---	---	0.11* (0.02)	0.12* (0.02)
		---	---	0.44* (0.04)	0.45* (0.04)	0.12* (0.02)
LIFELINE LOSS		---	---	---	0.25* (0.04)	---
		---	---	---	---	0.06* (0.01)
		---	---	---	0.25* (0.04)	0.06* (0.01)
CLOSURE		---	---	---	---	0.26* (0.04)
		---	---	---	---	---
		---	---	---	---	0.26* (0.04)

NOTE: \*p&lt;0.05

of business variable to deal with this problem. The non-normal distribution of the full-time employees variable was corrected by taking the natural log. The days closed variable was transformed by taking the square root. Missing data were listwise deleted, resulting in a decrease in the number of observations from 1110 to 610.

The initial model for predicting post-earthquake business preparedness, along with the path coefficients, are presented in Figure 2. Age of business, number of full-time employees, own or lease, firm or franchise, type of business (wholesale/retail, manufacturing, business/professional services, and finance/insurance/ real estate), previous disaster experience, and financial condition are thought to directly impact pre- and post-earthquake business preparedness. Pre-earthquake preparedness is proposed to directly effect physical damage, business closure, and post-earthquake preparedness. According to the model, physical damage directly affects both lifeline loss and business closure. Since it is difficult to operate a business without utilities, lifeline loss is directly related to business closure. Finally, because the experience of being forced to close should lead to a recognition of the need to plan for disasters, business closure is expected to have a direct effect on post-earthquake preparedness.

The goodness-of-fit statistics for the initial model show that it does not fit the data well. The chi-square was significant at 71.57 (33 df,  $p < 0.01$ ). The RMSEA for the initial model is 0.045 ( $p = 0.71$ ). The model's Akaike's Information Criterion (AIC) and the Consistent Akaike's Information Criterion (CAIC) are 245.57 and 713.94 respectively. The Goodness of Fit Index (GFI) and the Adjusted Goodness of Fit Index (AGFI) are 0.98 and 0.94. Nonetheless, this model does explain 16 percent of the variance in both pre- and post-earthquake preparedness respectively.

The standardized direct, indirect, and total effects for the initial model are presented in Table 3. A number of business characteristics have significant direct effects on pre-earthquake preparedness. For example, age of business (0.11), the number of full-time employees (0.24), and the financial condition of the business (0.10) are all positively related to pre-earthquake preparedness; older, larger, and more financially stable firms were more likely to prepare before the earthquake than younger, smaller, and less financially stable ones. Businesses in the finance, insurance, and real estate sector (0.14) were more likely than businesses in the "other" sector to prepare before the earthquake. Finally, disaster experience (0.08) is a significant predictor of pre-earthquake preparedness. Businesses reporting previous disaster experience were more likely to have prepared before the earthquake than firms reporting no previous disaster experience.

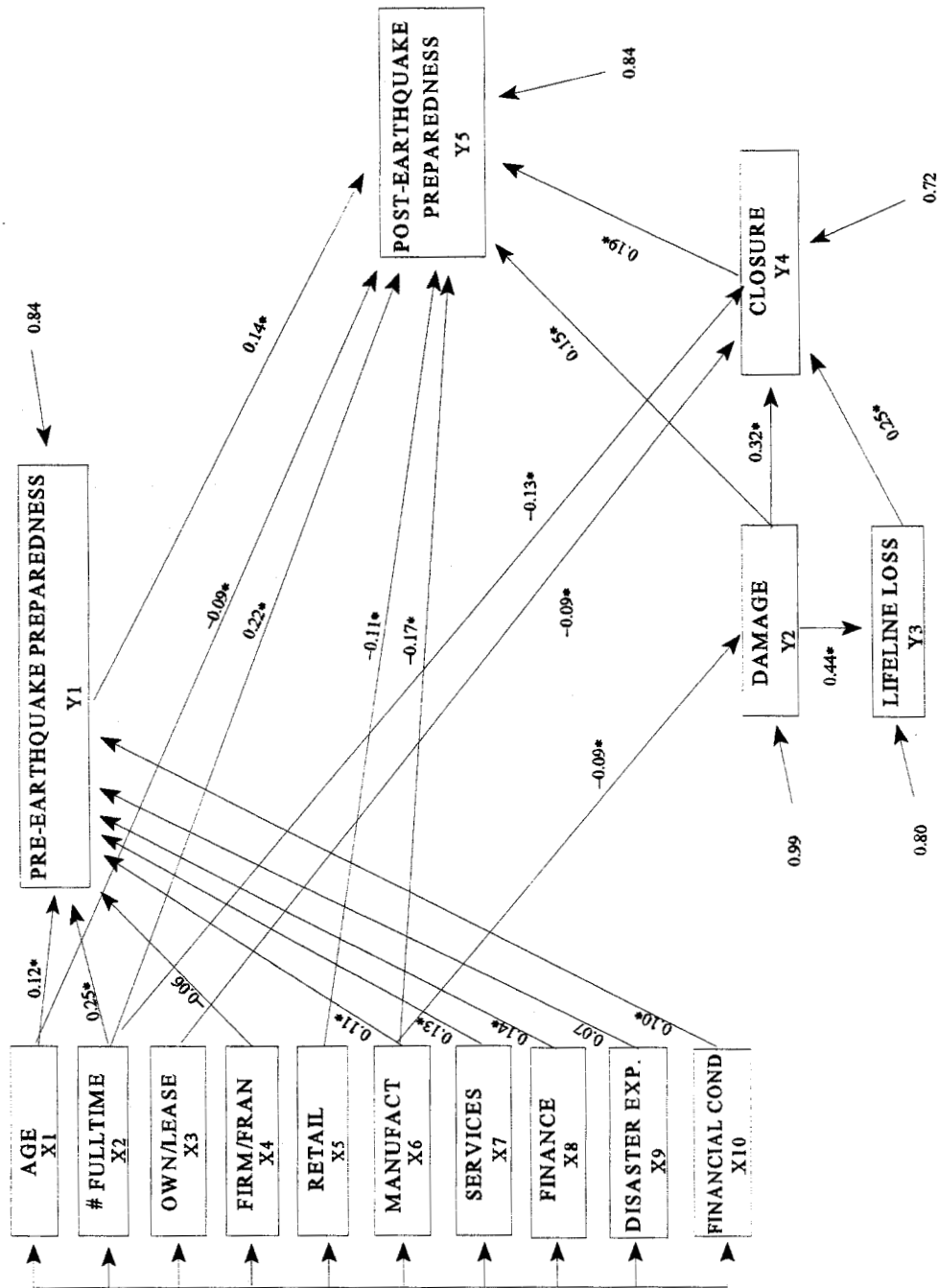
Five variables have significant, direct effects on post-earthquake preparedness including the age of the business (-0.08), the number of full-time employees (0.22), manufacturing businesses (-0.13), pre-earthquake levels of preparedness (0.13), and business closure (0.26). Consistent with the finding for pre-earthquake preparedness, larger businesses were more likely to prepare than smaller ones after the Northridge earthquake. While older businesses were significantly more likely than younger firms to prepare prior to the earthquake, the direction of the relationship changes for post-earthquake preparedness. Older firms were significantly less likely than younger firms to engage in preparedness activities after the earthquake. Type of business also influences post-earthquake preparedness; firms in the manufacturing and construction sector were significantly less likely than other businesses to prepare after the earthquake. Not surprisingly, pre-earthquake preparedness has a significant positive effect on preparedness after the Northridge earthquake. Higher levels of pre-earthquake preparedness lead to higher levels of

post-earthquake preparedness. Finally, the longer businesses were closed as a result of the Northridge earthquake the more likely they were to engage in post-earthquake preparedness activities. While these paths are significant, the model as a whole does not fit the data well and requires modification. Thus, no further elaboration or explanation of direct and indirect effects will be undertaken here. A more thorough discussion is presented with the final model.

The modification indices, expected change statistics, and T-scores were examined for possible relevant modifications. Using a combination of statistical data and logical inference, three paths were added and ten paths removed.

The final model of post-earthquake preparedness is presented in Figure 2. Table 4 shows the standardized direct, indirect, and total effects for the final model. This model explains 16 percent of the variance in pre-earthquake preparedness and 17 percent of the variance in post-earthquake preparedness. The goodness-of-fit statistics suggest that the model fits the data well. The chi-square is 41.21 (39 df,  $p=0.37$ ) and the final RMSEA is 0.010 ( $p=1.00$ ). The model AIC and CAIC are 203.21 and 639.27, respectively. The GFI and AGFI are 0.99 and 0.97. Again, these statistics suggest that the final model is a good fit to the data.

A number of business characteristics significantly and directly affect pre-earthquake preparedness. Consistent with previous research, the number of full-time employees (0.25) is the strongest predictor of pre-earthquake preparedness, with large businesses engaging in more preparedness activities than smaller ones. This result is likely due to the fact that larger firms have more personnel to devote to preparedness activities. As Mileti and associates (1993) noted, smaller businesses are less likely to have staff with preparedness activities as part of their jobs.



**Figure 3.** Final pre- and post-earthquake preparedness model  
 $(\chi^2=41.21 \text{ } p>0.05 \text{ } 39 \text{ df, RMSEA}=0.010 \text{ } p=1.00)$   
 NOTE: \* $p<0.05$

Table 4: Direct, Indirect, Total Effects, and (Standard Errors) for the Final Model of Pre- and Post Earthquake Preparedness

		PRE-EQ PREP	PHYS. DAMAGE	LIFELINE LOSS	CLOSURE	POST-EQ PREP
<i>Exogenous Variables</i>						
AGE	Direct	0.12* (0.04)	---	---	---	-0.09* (0.04)
	Indirect	---	---	---	---	0.02* (0.01)
	Total	0.12* (0.04)	---	---	---	-0.07 (0.04)
# FULLTIME		0.25* (0.04)	---	---	-0.13* (0.04)	0.22* (0.04)
		---	---	---	---	0.01 (0.01)
		0.25* (0.04)	---	---	-0.13* (0.04)	0.23* (0.04)
OWN/LEASE		---	---	---	-0.09* (0.04)	---
		---	---	---	---	-0.02* (0.01)
		---	---	---	-0.09* (0.04)	-0.02* (0.01)
FIRM/FРАН		-0.06 (0.04)	---	---	---	---
		---	---	---	---	-0.01 (0.01)
		-0.06 (0.04)	---	---	---	-0.01 (0.01)
RETAIL		---	---	---	---	-0.11* (0.04)
		---	---	---	---	---
		---	---	---	---	-0.11* (0.04)
MANUFACT		0.11* (0.04)	-0.09* (0.04)	---	---	-0.17* (0.04)
		---	---	-0.04* (0.02)	-0.04* (0.02)	-0.01 (0.01)
		0.11* (0.04)	-0.09* (0.04)	-0.04* (0.02)	-0.04* (0.02)	-0.17* (0.04)
SERVICES		0.13* (0.04)	---	---	---	---
		---	---	---	---	0.02* (0.01)
		0.13* (0.04)	---	---	---	0.02* (0.01)
FINANCE		0.14* (0.04)	---	---	---	---
		---	---	---	---	0.02* (0.01)
		0.14* (0.04)	---	---	---	0.02* (0.01)
DIS EXP.		0.07 (0.04)	---	---	---	---
		---	---	---	---	0.01 (0.01)
		0.07 (0.04)	---	---	---	0.01 (0.01)
FINANCIAL COND.		0.10* (0.04)	---	---	---	---
		---	---	---	---	0.01 (0.01)
		0.10* (0.04)	---	---	---	0.01 (0.01)
<i>Endogenous Variables</i>						
PRE-EQ PREP		---	---	---	---	0.14* (0.04)
		---	---	---	---	---
		---	---	---	---	0.14* (0.04)
PHYS. DAMAGE		---	---	0.44* (0.04)	0.32* (0.04)	0.15* (0.04)
		---	---	---	0.11* (0.02)	0.08* (0.02)
		---	---	0.44* (0.04)	0.44* (0.04)	0.23* (0.04)
LIFELINE LOSS		---	---	---	0.25* (0.04)	---
		---	---	---	---	0.05* (0.01)
		---	---	---	0.25* (0.04)	0.05* (0.01)
CLOSURE		---	---	---	---	0.19* (0.04)
		---	---	---	---	---
		---	---	---	---	0.19* (0.04)

NOTE: \*p&lt;0.05

Age of business (0.12) and financial condition (0.10) both have significant and direct effects on pre-earthquake preparedness. Older and more financially stable businesses were more likely to prepare prior to the Northridge earthquake. The lack of preparedness by new firms may be due to the fact that new businesses must necessarily invest a great deal of time and resources in the coordination and socialization of new employees. Furthermore, new businesses must compete with older established firms to secure customers and establish links to other relevant actors (Stinchcombe 1965). As a result, new businesses may not have the time and resources available to prepare for future disaster events. The finding that more financially stable businesses were more likely to prepare prior to the earthquake is not surprising. Simply put, financially stable firms have more resources available to them to invest in preparedness activities.

Type of business also has a significant impact on pre-earthquake preparedness. Businesses in the manufacturing (0.11), service (0.13), and f.i.r.e. (0.14) sectors were significantly more likely to prepare before the earthquake than businesses in the "other" category. Since manufacturing firms in the sample tended to be larger and older, the higher preparedness levels among these businesses is not surprising. However, the significant direct effect of the manufacturing variable on pre-earthquake preparedness indicates that other factors, independent of size and age, are at work. For example, the higher preparedness levels for manufacturing firms may be due to corporate mandates or the presence of safety officers. Similarly, the higher preparedness levels for finance, insurance, and real estate firms suggest this sector may be required to do more. The higher levels of preparedness among business and professional service firms is more difficult to explain since they tend to be smaller and older, factors that should work against them. Again, other factors seem to be influencing preparedness among these firms



independent of size and age. While less likely than for firms in the manufacturing and f.i.r.e. sectors, the preparedness levels among service firms may also be driven by corporate or governmental mandates. It is also possible that business associations representing service firms have worked very closely with member organizations to raise preparedness levels within this sector. It is clear that further exploration of the data is necessary to pinpoint the determinants of differing levels of preparedness among types of firms.

Like pre-earthquake preparedness, the number of full-time employees (0.22) is the strongest predictor of post-earthquake preparedness. Also, age and type of business significantly affect post-earthquake preparedness. Whereas age of business has a positive effect on pre-earthquake preparedness, it has a negative effect on post-earthquake preparedness (-0.09), indicating that it was younger businesses that were more likely to prepare after the Northridge earthquake. For younger businesses that may have tended to ignore the earthquake hazard prior to the event, the Northridge earthquake may have been a lesson or "wake up call" highlighting the need to engage in preparedness.

Businesses in the wholesale/retail (-0.11) and manufacturing (-0.17) sectors were significantly less likely than businesses in the "other" category to engage in post-earthquake preparedness. Along with firms in the f.i.r.e. sector, manufacturing and construction businesses had the highest levels of pre-earthquake preparedness. The higher levels of pre-earthquake preparedness among manufacturing and construction firms may have limited the opportunities for undertaking preparedness activities following the Northridge earthquake.

The significant negative relationship between firms in the wholesale and retail sector and post-earthquake preparedness is not surprising. The overall preparedness levels of these firms in

our sample are low. Businesses in this sector did not significantly engage in preparedness before the event and were significantly less likely than other businesses to engage in preparedness after the earthquake struck. While the data do not readily indicate possible determinants of their low levels of preparedness, it is clear that wholesale and retail firms in the Greater Los Angeles area should be the focus of local governmental preparedness efforts.

Not surprisingly, the variables measuring the direct and indirect impacts of the Northridge earthquake have some of the strongest effects on post-earthquake preparedness. For example, businesses reporting more types of physical damage (0.15) were more likely to step up their post-earthquake preparedness activities. The length of time the business was closed has a significant, positive effect on post-earthquake preparedness (0.19). The longer businesses were closed, the more likely they were to increase their preparedness levels following the earthquake. While lifeline loss does not have a direct significant effect on post-earthquake preparedness, it does have a significant, indirect effect through its influence on business closure (0.05). Businesses that reported more lifeline outages were closed for longer periods of time and therefore more likely to undertake additional post-earthquake preparedness measures. Consistent with the disaster literature, organizations are more likely to prepare after they have experienced a disaster event.

Finally, businesses that were already better prepared before the earthquake subsequently increased their preparedness levels (0.14). Such businesses may have had ongoing routines and procedures in place for engaging in preparedness activities. This would especially seem to be the case for firms in the service and F.I.R.E. sectors. Both types of firms had a significant and positive indirect effect on post-earthquake preparedness through pre-earthquake preparedness.

Other interesting paths surfaced in the final model. For example, business ownership had a significant, direct effect on business closure ( $-0.09$ ), with owners of their business property closing for shorter periods of time than lessees. This result may be due to the greater control owners have over the decision to open or close in the aftermath of the earthquake. Lessees may have had little choice in closing because owners forced them to close. Furthermore, the own/lease variable had a significant indirect effect on post-earthquake preparedness through business closure ( $-0.02$ ); building owners closed for shorter periods of time and therefore less likely to engage in post-earthquake preparedness.

The data suggest that levels of pre-earthquake preparedness did not have a significant effect on reducing any of the direct and indirect measures of earthquake impacts included in the model, such as physical damage, lifeline loss, or business closure. There are at least three possible reasons for this rather disturbing finding. First, while some businesses in the sample clearly did more than others to prepare before the earthquake struck, overall levels of preparedness among businesses were still relatively low. Perhaps preparedness had not yet reached a level that would make a difference. Second, one type of impact, lifeline loss, tends generally to originate outside the business property--for example, in damage to water or electrical transmission and distribution systems. Preparedness efforts at the level of the individual business are not capable of making a difference in these kinds of impacts--although good planning can help businesses cope with lifeline outages. Finally, additional variables, such as the type of structure housing the business, distance of the business property from the earthquake's epicenter, and the ground shaking intensity experienced at the business site, are probably related to the damage and disruption businesses experienced. However, they were not taken into account in this model. Inclusion of such

variables in future analyses will help shed light on whether recommended preparedness practices such as those studied here actually do help businesses contain losses.

Finally, disaster experience prior to the Northridge earthquake did not have a significant effect on either pre- or post-earthquake preparedness. With respect to pre-earthquake preparedness, this non-existent relationship may be due to a lack of previous earthquake-specific experience. Surprisingly, in a hazardous region, only 36.1 percent of the firms in the sample reported experience with disasters prior to the Northridge earthquake. Of these, only 27 percent reported experience with an earthquake. Thus, only 9.4 percent of the businesses in the total sample reported experience with an earthquake prior to the Northridge event. By far, the majority of respondents reported experience with riots or civil unrest. Of the 36 percent with disaster experience, 85 percent reported experiencing a riot, with 65 percent specifically mentioning the 1992 Los Angeles riot. The lack of earthquake experience, along with the fact that the survey focused to some degree on earthquake-specific preparedness measures, may explain the non-significant impact of previous disaster experience on pre-earthquake preparedness. For post-earthquake preparedness, it appears that the impacts of the Northridge earthquake superseded the impact of previous disaster experience resulting in a non-significant effect of the latter on the former.

## **DISCUSSION/CONCLUSION**

Overall, the final model predicted pre- and post-earthquake preparedness reasonably well. However, a large amount of variance in each of the preparedness variables was left unexplained in the model. The results indicate that pre-earthquake preparedness is partly a function of the age of

the business, the number of full-time employees, the type of business, and the financial condition of the business. The strongest predictor of this group was the number of full-time employees. Again, this is consistent with past research that shows that larger businesses engage in more preparedness activities than smaller ones. Post-earthquake preparedness is predicted by pre-earthquake preparedness, effects of the Northridge earthquake (physical damage, lifeline loss, and business closure), the age of the business, the number of full-time employees, and the type of business. As with pre-earthquake preparedness, the strongest effect on post-earthquake preparedness was the number of full-time employees. The next largest influences were the impacts of the Northridge earthquake itself.

Given the frequency of disaster events in the region, it was assumed that Los Angeles and Santa Monica businesses would be better prepared. However, preparedness levels among businesses in the region were relatively low. On average, businesses engaged in only four of sixteen preparedness activities both before and after the Northridge earthquake. These figures are consistent with other findings in the literature (Dahlhamer and D'Souza forthcoming; Drabek 1994a; Mileti et al. 1993).

Although preliminary, these results suggest that the current approach to encouraging loss reduction among businesses, which stresses raising awareness of the earthquake problem and voluntary implementation of preparedness measures, is not working. Even in hazard-prone areas like Los Angeles, businesses find it difficult to undertake even basic disaster preparedness measures. Greater Los Angeles is exposed to a range of hazards and in recent years has experienced earthquakes (e.g., the 1987 Whittier Narrows event), major wildfires, flash floods, and the most serious episode of urban unrest in a generation. Los Angeles residents, including

business owners, are aware that the environment is hazardous. What is lacking is not awareness, but rather resources, incentives, and technical assistance to help business owners address hazard-related problems. Interventions that might make a difference include forming and strengthening business-government alliances such as Southern California's Business and Industry Council on Emergency Planning and Preparedness (BICEPP); making low interest loans available for the structural retrofitting of hazardous buildings; taking disaster preparedness into account in the setting of insurance rates; allowing tax credits for hazard reduction activities; and, where necessary, legally mandating the adoption of certain preparedness measures. Our data indicate that certain types of businesses, such as small firms and retail businesses, have more problems than others in undertaking preparedness measures. This suggests that special programs targeting these types of businesses are needed. Preparing for disasters must compete with many other issues and concerns, and the average business owner undoubtedly worries much more about day-to-day problems than about getting ready for the next disaster. It is likely that preparedness programs will succeed only to the extent that they can be shown to offer concrete financial benefit in the short term.

## WORKS CITED

- Alesch, D. J., C. Taylor, A. S. Ghanty, and R. A. Nagy. 1993. "Earthquake Risk Reduction and Small Business." Pp. 133-160 in K. J. Tierney and J. M. Nigg (eds.), Socioeconomic Impacts. Monograph prepared for the 1993 National Earthquake Conference. Memphis, TN: Central United States Earthquake Consortium.
- Banerjee, M. M. and D. F. Gillespie. 1994. "Strategy and Organizational Disaster Preparedness." Disasters 18(4): 344-354.
- Barlow, H. D. 1993. "Safety Officer Accounts of Earthquake Preparedness at Riverside Industrial Sites" International Journal of Mass Emergencies and Disasters. 11(3): 421-435.
- Dahlhamer, J. M. and M. J. D'Souza. Forthcoming. "Determinants of Business Disaster Preparedness in Two U.S. Metropolitan Areas" International Journal of Mass Emergencies and Disasters.
- Dillman, D. 1978. Mail and Telephone Surveys: The Total Design Method. New York: Wiley.
- Disaster Research Center. 1993. Comparative Analysis of Community Disaster Recovery. Final Report to the National Science Foundation. Newark, Delaware: Disaster Research Center, University of Delaware.
- Drabek, T. E. 1995. "Disaster Responses Within the Tourist Industry." International Journal of Mass Emergencies and Disasters. 13(1):7-23.
- Drabek, T. E. 1994a. "New Study Shows that Growing Tourist Industry is Inadequately Prepared for Emergencies." Hazard Technology. 14(1):17,21.
- Drabek, T. E. 1994b. Disaster Evacuation and the Tourist Industry. Boulder, Colorado: Institute of Behavioral Science, University of Colorado.
- Drabek, T. E. 1991. "Anticipating Organizational Evacuations: Disaster Planning by Managers of Tourist-Oriented Private Firms." International Journal of Mass Emergencies and Disasters. 9(2): 219-245.
- Drabek, T. E. 1986. Human System Responses to Disaster: An Inventory of Sociological Findings. New York: Springer-Verlag.
- Francoaviglia, R. 1978. "Xenia Rebuilds--Effects of Pre-Disaster Conditioning on Post-Disaster Redevelopment." Journal of the American Institute of Planners. 44:13-24.

- Gabor, T. 1981. "Mutual Aid Systems in the United States for Chemical Emergencies." Journal of Hazardous Materials. 4:343-356.
- Joreskog, K. and D. Sorbom. 1993. LISREL8: User's References Guide. Chicago: Scientific Software International.
- Mileti, D. S., T. E. Drabek, and J. E. Haas. 1975. Human Systems in Extreme Environments. Institute of Behavioral Science, University of Colorado, Boulder, Colorado.
- Mileti, D. S., J. D. Darlington, C. Fitzpatrick, and P. W. O'Brien. 1993. Communicating Earthquake Risk: Societal Responses to Revised Probabilities in the Bay Area. Fort Collins, CO: Hazards Assessment Laboratory and Department of Sociology, Colorado State University.
- Nigg, J. M. 1995. "Disaster Recovery as a Social Process." Pp. 81-92 in Wellington After the Quake: The Challenge of Rebuilding Cities. Wellington, New Zealand: Earthquake Commission and the Centre for Advanced Engineering.
- Perry, R. W. 1979. "Evacuation Decision Making in Natural Disasters." Mass Emergencies 4:25-38.
- Perry, R. W. and M. R. Greene. 1982. "The Role of Ethnicity in Emergency Decision-Making Processes." Sociological Inquiry 52:306-334.
- Quarantelli, E.L., C. Lawrence, K. J. Tierney, and T. Johnson. 1979. Initial Findings from a Study of Socio-Behavioral Preparations and Planning for Acute Chemical Hazard Disasters. Columbus, Ohio: Disaster Research Center, The Ohio State University.
- Stinchcombe, A. 1965. "Social Structure and Organizations." Pp. 142-193 in J. G. March (ed.), Handbook of Organizations. Chicago: Rand McNally.
- Tierney, K. J. 1995. "Impacts of Recent U.S. Disasters on Businesses: The 1993 Midwest Floods and the 1994 Northridge Earthquake". Paper presented at the National Center for Earthquake Engineering Research Conference on Economic Consequences of Earthquakes: Preparing for the Unexpected, New York, N.Y., September 12-13, 1995.
- Tierney, K. J. 1994. "Business Vulnerability and Disruption: Data from the 1993 Midwest Floods". Paper presented at the 41st North American Meetings of the Regional Science Association International, Niagara Falls, Ontario, November 16-20.