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PREDICTING BUSINESS FINANCIAL LOSSES IN THE 1989 LOMA PRIETA AND 1994 NORTHRIDGE EARTHQUAKES: IMPLICATIONS FOR LOSS ESTIMATION RESEARCH

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INTRODUCTION

Spurred in part by the rising economic costs of natural disasters, there has recently been a dramatic increase in the number of studies aimed at estimating financial losses caused by large-scale earthquakes. For example, in 1997 the journal *Earthquake Spectra* devoted an entire issue to this topic. Papers appearing in the special issue ranged from cost-benefit analyses of structural rehabilitation strategies (D'Ayala et al., 1997) to the development of real-time damage assessment tools (Eguchi et al. 1997). In 1998 the Multidisciplinary Center for Earthquake Engineering Research published a monograph addressing the engineering and socioeconomic impacts of earthquakes (Shinozuka, Rose, and Eguchi, 1998). A primary focus of the report was on the regional economic impacts of earthquake-induced electricity lifeline disruptions. More recently, in 1999 the National Research Council Committee on Assessing the Costs of Natural Disasters published a report outlining a framework for loss estimation (National Research Council, 1999). The Committee's primary goals were to develop a framework for consistent and systematic collection of loss data from natural disasters and to build an institutional capacity for collecting such data.

This recent interest in loss estimation research has been facilitated by technological advances that improve our ability to make relatively accurate, real-time estimates of losses from major disaster events. While loss estimates from actual or scenario disasters have traditionally been used as planning tools, practitioners are now increasingly able to use real-time loss estimates for prioritizing response and recovery tasks. For example, emergency responders can use such data to organize search and rescue activities. Lifeline organizations may also find this sort of information useful for pinpointing system failures and prioritizing needed repairs. In a longer time frame, such data may be useful for identifying severely impacted populations that have special recovery needs. Indeed, following the Northridge earthquake, state and federal officials used loss estimation data--generated by EPEDAT, or the Early Post-Earthquake Damage Assessment Tool--for making key program and policy decisions.[1]

This study attempts to make a contribution to the loss estimation literature by addressing the impacts of the 1989 Loma Prieta and 1994 Northridge earthquakes on businesses. While it builds upon work that has already been done in the area, the present study departs from previous loss estimation studies in important ways. First, much of the existing research on estimating the economic impacts of disasters utilizes a community, regional, or even national level of analysis (Rossi et al., 1978; Wright et al., 1979; Cohen, 1993; West and Lenze, 1994; Rose and Benavides, 1998). Unlike these previous studies, the current research attempts to identify factors related to financial losses at the individual business level. This alternative level of analysis will aid in the production of more accurate loss estimates at the aggregate level and allow for the identification of risk factors that are associated with higher vulnerability to disaster impacts.

Another feature of the present study is that it takes into account both losses due to physical damage and business interruption losses. The primary loss measure used in the analysis is not based on physical damage alone; rather, it also incorporates losses due to business closure, which may or may not be induced by actual damage to the structure housing the business. In addition, along with characteristics of the firms and a measure of earthquake shaking intensity, the analysis also models the effects of lifeline interruptions on total dollar losses. This is

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[1] For a more thorough discussion of EPEDAT, see Eguchi et al. (1997).

consistent with other recent efforts to estimate regional economic losses due to lifeline failures (Shinozuka, Rose and Eguchi 1998; Rose and Benavides, 1998). The major benefit of these new approaches to loss estimation is that they move beyond narrow definitions of disaster effects that only take into account factors like direct physical damage.

By focusing on the individual business level of analysis and both direct and business interruption impacts, this study has important methodological and policy implications. In a policy sense, the analysis will be useful in identifying particular types of businesses that are most vulnerable to the economic impacts of disasters. Related to that, this analysis will make important methodological contributions by identifying loss predictors that should be included in subsequent loss estimation modeling efforts.

The remainder of this report consists of three sections. First, we describe the methodology used for collecting the data and conducting the analyses. It also includes a description of variable measurement and descriptive statistics for each model predictor. Next, we present the results of the multivariate analyses, highlighting key similarities and differences between the two study communities (Greater Los Angeles and Santa Cruz County). Finally, the paper concludes with a discussion of the key methodological and policy implications of this study, suggesting new avenues for future loss estimation research.

METHODOLOGY

Sampling

Businesses for the Greater Los Angeles survey were selected using a three-stage stratified sampling design, with shaking intensity and type and size of business used as stratifying variables. In the first stage of the design, Greater Los Angeles area businesses were aggregated into high (Mercalli VIII and IX) and low (Mercalli VI and VII) shaking intensity zip codes. In the second stage, businesses in the high and low MMI zip codes were aggregated by Standard Industrial Codes into five economic sectors: wholesale and retail; manufacturing construction, and contracting; business and professional services; finance, insurance, and real estate; and "other" businesses. The latter category consists of firms involved in agriculture, forestry, 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 (20 or more employees) firms in each of the five industrial sectors.

The sampling strategy for Santa Cruz County was slightly different because the basic research questions addressed in the two surveys differed.[2] The Northridge survey focused on short-term earthquake impacts, whereas the Santa Cruz study looked at the long-term consequences of disaster impacts on businesses. To be considered for inclusion in the study, a business had to have been in existence at the time of the Loma Prieta earthquake (1989) and still in existence at the time the survey was administered (Summer 1997). According to Dun & Bradstreet, only 3,075 businesses met this criteria; therefore, it was possible to include the entire population of businesses in the study rather than drawing a sample.

The data for both surveys were collected through 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 phone calls. With an initial sample size of 4,752, mailings for the

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[2]For ease of discussion, Greater Los Angeles and Santa Cruz County will be referred to as Northridge and Santa Cruz throughout the remainder of the paper.

Northridge survey began in May, 1995, approximately 16 months after the earthquake. In all, 1,110 surveys were received and coded, reflecting a 23 percent response rate. Mailings for the 3,075 Santa Cruz County businesses began in June, 1997. Of those, 933 firms returned a completed questionnaire producing a 34 percent response rate.[3]

Variable Measurement

Dependent variable. The total loss measure employed in the analysis is the sum of dollar losses due to physical damage and business closure. Businesses that did not experience physical damage or closure were given a dollar loss figure of zero. This measure is somewhat limited because it only includes those losses incurred from direct physical damage and/or business closure; nevertheless, it does provide some indication of the financial impacts of disasters on private enterprises. Because the distributions on the total dollar loss figure for both data sets were highly skewed, ordinal measures were created and used for modeling purposes (see Table 1).

Table 1 about here

Independent variables. Table 1 describes the coding scheme for each of the independent variables included in the subsequent analyses. The same set of independent variables was employed in a comparative analysis of total dollar losses for both study areas, though additional

[3]In the course of administering the survey, 299 firms were removed from the population for a variety of reasons, including: 1) the business was not actually in existence at the time of the event; 2) the business was not operating in Santa Cruz County at the time of the disaster; 3) the business closed prior to data collection; 4) the organization that received the survey was not a private, for-profit firm; and 5) the firm could not be located after exhaustive searches. The deletion of these cases reduced the population figure from 3,075 to 2,776. This latter figure was then used to compute the response rate of 34 percent.

variables not available for Santa Cruz County were integrated into a full model for Northridge. The comparable independent variables that were available for both study areas and employed in the comparative analysis include business characteristics (size and sector[4]) and measures of indirect disaster impacts (loss of electricity, telephones, and water).[5] The additional variables included in the full model for Northridge are year of construction of the building housing the business and the maximum peak ground acceleration recorded for the zip code in which the firm was located at the time of the earthquake.

Descriptive Statistics

Table 2 provides descriptive statistics for the independent and dependent variables included in the analysis. In terms of firm characteristics, the median size of Northridge businesses was 6.0 full-time equivalent employees (FTEs), and for Santa Cruz the median was 4.5 FTEs. Looking at economic sector, the breakout for Northridge firms is as follows: wholesale or retail (25.1 percent), manufacturing (13.6 percent), services (36.1 percent), f.i.r.e. (13.0 percent), and "other" (12.2 percent). The distribution of Santa Cruz firms follows a similar pattern: wholesale or retail (31.0 percent), manufacturing (17.7 percent), services (34.8 percent), f.i.r.e. (10.0 percent), and "other" (6.5 percent).

Table 2 about here

[4]In the regression models, manufacturing, construction, and contracting and "other" firms serve as the reference category. Given the exploratory nature of this research, this decision was based on statistical criteria as these firms generally reported the lowest losses among types of firms across the two study communities.

[5]Physical damage and business closure were not included in the analyses of total dollar losses because, as explained earlier, the dependent variable is based on losses due to these disaster impact measures.

As Table 2 shows, lifeline disruption was much more prevalent in Santa Cruz than in Northridge. For example, 91.1 percent of Santa Cruz firms lost electricity compared to 61.1 percent who lost this service in Northridge.[6] Similarly, 54.3 percent of Northridge firms reported a loss of telephone service, whereas 75.0 percent of Santa Cruz firms lost telephones for some period of time. Finally, while only 18.9 percent of Northridge firms lost water service, more than twice as many Santa Cruz firms lost this service (39.4 percent).

Descriptive statistics for maximum PGA and year of construction, which were only available for Northridge, are also presented in Table 2. As Table 2 shows, nearly 75 percent of Northridge firms were located in areas experiencing a maximum PGA of .42 or higher. Looking at year of construction, more than 40 percent of Northridge businesses were located in structures built prior to 1960. The remaining firms were about evenly distributed across the two remaining categories of year of construction: 29.7 percent were located in buildings constructed between 1960 and 1976; and 28.7 percent were housed in structures built after 1976.

Finally, Table 2 presents descriptive statistics for the dependent variable, total dollar losses. While on average, Northridge firms reported greater overall losses (mean=$113,041) than

their Santa Cruz counterparts (mean=$81,115), the median suggests that Santa Cruz firms incurred greater losses (Northridge=$2,000; Santa Cruz=$5,000).

RESULTS

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[6]Although there is little variation in the loss of electricity variable in Santa Cruz, it was included in the model because previous studies have highlighted the importance of including lifeline interruption measures in loss estimation research (Chang, 1998).

Table 3 presents the results of the standard OLS regressions on total dollar losses for Santa Cruz County and Northridge. The first two columns of this table directly compare the two communities on the same set of independent variables and the third column presents a full model for Northridge with year of construction and shaking intensity added to the regression equation. While the F-values for the first two models indicate that the model fits the data well, a greater proportion of variance in total dollar losses was explained by the independent variables in Northridge (R^2=.29) than in Santa Cruz (R^2=.14). While not verifiable with the existing data, the greater explanatory power of the model when applied to Northridge may be due to differences in the time elapsed between the events and the administration of the surveys. For example, given the longer time frame involved in the Santa Cruz study, financial loss data may be less accurate due to problems of respondent recollection or changes in management/ownership.

Table 3 about here

In terms of predicting total dollar losses, five significant predictors emerged in the first two models. In both study areas, size was a significant predictor with larger firms reporting greater total dollar losses than their smaller counterparts. Indeed, in Santa Cruz size of the business was the strongest predictor of losses as indicated by the standardized coefficient (Beta) of .24. Figure 1 illustrates clearly the relationship between business size and total dollar losses in Santa Cruz County, with losses dramatically increasing among the largest firms. Among businesses in Northridge, the relationship between size and losses is less straightforward as depicted in Figure 2. The weaker impact of size (Beta=.15) on losses in Northridge may be due to a possible curvilinear relationship between the two variables that was not explored in this analysis. This is an important point that will be considered in subsequent analyses of these data and should also be addressed in future loss estimation research.

Figure 1 and Figure 2 about here

The significant, positive relationship between size and total dollar losses is in some ways not surprising. By virtue of their size, larger firms typically have greater financial assets than smaller businesses. This point is confirmed by significant, positive correlations between business size and financial condition in both data sets (Santa Cruz: $r=.09$, $p=.006$; Northridge: $r=.24$, $p=.000$). It is plausible, then, that larger businesses sustain greater financial losses in disaster situations because they simply have more to lose.[7]

As shown in Table 3, business sector also plays an important role in predicting total dollar losses. In both communities, wholesale and retail businesses as well as services firms reported significantly greater losses than manufacturing and "other" firms. However, the coefficients for wholesale and retail establishments and services firms exerted a greater influence on losses in Northridge (Beta=.16 and .12) than in Santa Cruz (Beta=.13 and .09). Additionally, finance, insurance, and real estate firms in Northridge reported significantly

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[7] While larger firms sustain greater overall financial losses, the impacts are more devastating to smaller businesses when losses are calculated on a per employee basis. When losses are standardized in this manner (total dollar losses/FTEs), small businesses (<20 FTEs) report greater median losses than larger ones (>=20 FTEs). For example, small Santa Cruz firms report median per employee losses of $1,000, while their large counterparts report median per employee losses of $352. In Northridge, the figures for small and large firms are $850 and $31 respectively.

greater losses than their manufacturing and "other" businesses. The relationship between sector and total dollar losses is also depicted in Figures 3 and 4. For example, while the median dollar loss figures for the entire Northridge and Santa Cruz County samples are $2,000 and $5,000, respectively, the figures for wholesale and retail firms for both study areas exceed these thresholds (N=$3,550; SC=$6,000). Also, notice that among Northridge businesses f.i.r.e. firms had the highest median dollar losses, but in Santa Cruz County the losses for these firms were among the lowest.

Figure 3 and Figure 4 about here

There are variety of possible explanations for these sectoral differences. For example, wholesale and retail firms were less likely than other types of businesses in Northridge to engage in disaster preparedness activities that may contain financial losses (r=-.13, p=.000); and in Santa Cruz wholesale and retail firms were more likely to close (r=.10, p=.004) and to experience various operational problems (r=.08, p=.014). Services firms in Northridge were more likely than other types of firms to experience physical damage from the earthquake (r=.08, p=.012). Finally, f.i.r.e. establishments in Northridge (r=.10, p=.001) and services firms in Santa Cruz (r=.07, p=.047) were in better financial condition than other types of businesses prior to the earthquake, suggesting they--like larger businesses--had greater financial assets at risk. Given the range of possible explanations, future loss estimation research should pay close attention to the relationship between business sector and disaster losses to understand why certain types of firms are more vulnerable to hazardous events.

The loss of vital lifelines in disaster situations also plays an important role in predicting total dollar losses. Looking at Table 3, businesses that lost electricity reported significantly greater losses in both study communities, as did firms losing water service. The loss of telephone service was also an important predictor of losses among Northridge firms, with firms losing telephones incurring significantly higher losses. However, the loss of telephones exerts a rather weak influence on total dollar losses (Beta=.09) among Northridge firms. Interestingly, while the loss of water was a fairly strong predictor of losses in both communities (Northridge Beta=.27; Santa Cruz Beta=.20), the loss of electrical service was a much stronger predictor of losses in Northridge (Beta=.28) than in Santa Cruz County (Beta=.08). In fact, the loss of electricity is the strongest predictor of total dollar losses in the initial Northridge model.

The greater impact of the loss of electricity on total dollar losses among Northridge firms is interesting and may be due to its relationship with business closure. Bivariate analyses involving closure indicate that the loss of electricity was more strongly associated with closure in Northridge (r=.41, p=.000) than in Santa Cruz (r=.24, p=.000). Furthermore, although electrical service was restored rather quickly in both study communities, Santa Cruz firms generally remained closed for longer periods of time. This suggests, then, that factors other than the loss of electrical service contributed to the greater length of inactivity and therefore greater losses among Santa Cruz firms. Hence, it is not surprising that among businesses that closed in Northridge, the loss of electricity was one of the most frequently mentioned reasons for closing.

Another way of looking at the relationship between the interruption of lifelines and losses is to consider the duration of outage. Figures 5, 6, and 7 clearly demonstrate a ramping up of losses for Northridge businesses: the longer a firm goes without a key lifeline service the greater its losses.[8] For example, losses remain fairly low when moving from no electricity outage to 24 hours of interruption. Beyond 24 hours of service interruption, however, losses begin to escalate dramatically (see Figure 5). A similar relationship emerges between the duration of telephone outage and median total dollar losses sustained by Northridge businesses. While a similar ramping of losses is observed with regard to the duration of water outage, Figure 7 also shows that any interruption of water service is costly. These findings suggest that short interruptions in telephone and electrical services result in relatively small losses, but even a short water outage can be very costly to businesses. At any rate, disruptions of key lifeline services are important contributors to a firm's overall losses in a disaster.

Figure 5, Figure 6, and Figure 7 about here

Table 3 also presents the results of a full model for Northridge that includes the original set of independent variables along with measures of shaking intensity (maximum peak ground acceleration) and year of construction.[9] For the most part, the findings for the full model are consistent with the initial Northridge regression, but there are some notable differences. For example, the overall explanatory power of the model increases by four percent with the addition of the new variables (R^2=.33 versus .29). Among the original set of predictors, the relationships remain the same with the exception of telephone service outage which drops from statistical significance. In terms of the new variables, maximum peak ground acceleration is significantly

[8] Comparable graphs for Santa Cruz County firms are not available because questions on duration of outages were not included in the survey.

[9] Comparable measures of shaking intensity and year of construction were not obtained for Santa Cruz County.

related to total dollar losses, emerging as the second strongest predictor (Beta=.22). Not surprisingly, firms located in areas experiencing more intense shaking reported overall greater losses. This relationship is illustrated graphically in Figure 8. While almost nonexistent at low levels, losses substantially increase with greater shaking intensity.

Figure 8 about here

While not reaching statistical significance, the relationships between the year of construction measures and total dollar losses are very interesting and somewhat surprising. For example, firms housed in buildings constructed after 1976 reported much greater losses than those located in structures built prior to 1960. Thus, businesses operating in the newest structures sustained the highest losses among all firms in the sample, which is nicely illustrated in Figure 9. While businesses in pre-1960 structures reported median dollar losses of about $1,000, median losses for firms in post-1976 buildings exceeded $5,000. This seemingly ironic relationship may be due to the proximity of newer structures to the epicenter of the earthquake. The Northridge area, where shaking intensity was extremely high, is characterized by recent growth and development. This is in contrast to other parts of the Greater Los Angeles area--such as downtown LA--that have a higher concentration of older buildings but experienced less shaking from the earthquake. Again, the relationships between year of construction and total dollar losses were not statistically significant, but they suggest the need for further exploration in future loss estimation research.

Figure 9 about here

CONCLUSIONS

The purpose of the study was to identify factors associated with business financial losses from two major earthquake disasters. Models including firm characteristics and disaster impacts were developed to predict losses among businesses in Santa Cruz County and the Greater Los Angeles area. In addition, a full model was developed for the Los Angeles study area that included the original set of loss predictors along with measures of shaking intensity and year of building construction. Overall, the models predicted business financial losses reasonably well, although a fair amount of variance was left unexplained, particularly in the analysis of Santa Cruz County firms. For example, the initial and full models for Northridge explained 29 percent and 33 percent, respectively, whereas the model for Santa Cruz County firms explained about 14 percent of the variance in financial losses.

The original models for both study communities produced remarkably similar results. In both areas the following types of firms sustained significantly greater financial losses: larger firms, wholesale or retail businesses, firms in the services sector, and businesses that lost electricity and/or water. In addition, Northridge firms in the finance, insurance, and real estate sector and those that lost telephone service reported significantly greater total dollar losses. For Santa Cruz County, the strongest predictor of total dollar losses was firm size, and for Northridge the strongest predictor was the loss of electrical service. In terms of the Northridge full model, the same set of significant loss predictors were identified with the exception of the loss of telephone service. Also, in the full model peak ground acceleration emerged as the second strongest predictor of total dollar losses behind the loss of electricity.

The findings of this research suggest a number of important methodological and policy implications. From a methodological standpoint, variables such as firm size, economic sector, and direct and indirect disaster impacts (e.g., shaking intensity and lifeline outages) need to be included in future loss estimation research. Moreover, the moderate explanatory power of the models in this research indicates a need for the inclusion of additional variables such as disaster preparedness and type of structure in which businesses are housed. In theory, various preparedness and mitigation actions should contain or reduce disaster losses, though this is really an empirical question that can be addressed through future loss estimation research.[10] Type of structure is also important to consider because previous research has documented that certain types of construction are more vulnerable to disaster impacts (e.g., unreinforced masonry buildings in earthquake events), and that potentially increases the vulnerability of firms housed in those structures.[11]

Additional disaster impact measures, such as physical damage and business closure, should also be included in future loss estimation modeling efforts. This raises some other interesting methodological implications of this research. Because the dependent variable in this analysis was contingent upon physical damage and business closure, it was not possible to incorporate these disaster impact measures as model predictors. Clearly, there is a need for

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[10] Measures of predisaster preparedness were not included in this analysis due to large amounts of missing data among Northridge firms.

[11] Structural type data were obtained for the Northridge sample in this study but were of limited use for two reasons. First, this information was collected by a county assessor's office for purposes other than research. Thus, it was not possible to develop meaningful structural type categories. For example, brick, block, concrete frame, and other types of concrete or masonry structures (e.g., unreinforced masonry) were given the same code in the county assessor's database. Second, the attempt to match the county assessor's information with the Northridge survey data resulted in excessive amounts of missing cases.

primary data collection efforts to obtain overall loss figures that are not contingent on potential model predictors (e.g., physical damage and business closure). Subsequent analyses could then be done to identify the significant determinants of those losses. The findings of this type of research could then be used to calibrate existing loss estimation methodologies and produce more accurate loss estimates.

In terms of policy implications, the results of the present study suggest that certain types of businesses are more vulnerable to the financial impacts of disasters. For example, the results consistently show that wholesale/retail and services firms tend to incur greater total dollar losses from disasters than other types of businesses. Also, the findings consistently show firm size to be significantly related to total dollar losses. Although larger businesses report greater losses, the financial impacts of disasters are far more devastating for smaller firms when losses are standardized on a per-employee basis. Therefore, communities should strongly consider economic sector and business size in the development and implementation of business loss reduction programs and policies. Such consideration would likely improve the effectiveness of those programs aimed at containing or reducing disaster losses.

Finally, the results of this research clearly suggest the need to broaden our conceptions of disaster impacts. Traditionally, researchers and policymakers have focused narrowly on direct disaster impacts such as physical damage to a business property, but this study highlights the need to also consider indirect impacts such as lifeline outages. While business owners can take certain actions, such as purchasing electrical generators and cellular phones, to minimize the consequences of lifeline interruptions, they cannot prevent the loss of crucial services. That would require a broader community-wide effort to make lifelines and other key elements in the public infrastructure more resistant to disaster impacts.

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Table 1. Variable Definitions

Variable	Coding Scheme	Description
Independent Variables:		
Full-time employees[a]	continuous	Number of full-time equivalent employees at the time of the earthquake
Wholesale or retail	0=Manufacturing, construction, or contracting/"other" 1=Wholesale or retail	Whether or not the business was a wholesale or retail firm at the time of the earthquake
Finance, insurance, or real estate	0=Manufacturing, construction, or contracting/"other" 1=Finance, insurance, or real estate	Whether or not the business was a finance, insurance, or real estate firm at the time of the earthquake
Services	0=Manufacturing, construction, or contracting/"other" 1=Services	Whether or not the business was a business or professional services firm at the time of the earthquake
Loss of electricity	0=No 1=Yes	Whether or not the firm lost electricity as a result of the earthquake
Loss of telephones	0=No 1=Yes	Whether or not the firm lost telephones as a result of the earthquake
Loss of water	0=No 1=Yes	Whether or not the firm lost water as a result of the earthquake

Table 1. (continued)

Variable	Coding Scheme	Description
Peak ground acceleration (Northridge only)	4-point scale	Maximum peak ground acceleration recorded for the zip code in which the business was located at the time of the earthquake
Year built (1960-1976) (Northridge only)	0=Structure built prior to 1960 1=Structure built between 1960 and 1976	Whether or not the firm was housed in a structure built between 1960 and 1976
Year built (Post-1976) (Northridge only)	0=Structure built prior to 1960 1=Structure built after 1976	Whether or not the firm was housed in a structure built after 1976
Dependent Variables:		
Total dollar losses	1=$0 2=$1,000-$2,999 3=$3,000-$9,999 4=$10,000-$39,999 5=$40,000 and above	Dollar losses due to business closure and physical damage

[a] Natural log of full-time employees was taken in subsequent analyses to correct for a non-normal distribution.

Table 2. Descriptive Characteristics of Model Variables

Variable	Northridge	Santa Cruz
Independent Variables:		
Number of full-time equivalent employees		
Mean:	41.1	14.7
Median:	6.0	4.5
	(N=1,059)	(N=909)
Type of business		
% wholesale/retail	25.1	31.0
% manufacturing/ construction/ contracting	13.6	17.7
% services	36.1	34.8
% finance/insurance/ real estate	13.0	10.0
% "other"	12.2	6.5
	(N=1,110)	(N=933)
Percent lost electricity	61.1	91.1
	(N=1,091)	(N=919)
Percent lost telephones	54.3	75.0
	(N=1,082)	(N=917)
Percent lost water	18.9	39.4
	(N=1,093)	(N=913)
Maximum peak ground acceleration		
% .13	6.0	-----
% .24	20.9	-----
% .42	44.6	-----
% .75	28.5	-----
	(N=1,110)	

Table 2. (continued)

Variable	Northridge	Santa Cruz
Year of construction		
% built prior to 1960	41.6	-----
% built between 1960 and 1976	29.7	-----
% built after 1976	28.7	-----
	(N=926)	
Dependent Variable:		
Total dollar losses		
Mean:	113,041	81,115
Median:	2,000	5,000
	(N=925)	(N=752)

Table 3. Regression (OLS) Results for Total Dollar Losses

Variable	Santa Cruz Unstd. Coeff.	Santa Cruz SE	Santa Cruz Std. Coeff.	Northridge (initial) Unstd. Coeff.	Northridge (initial) SE	Northridge (initial) Std. Coeff.	Northridge (full) Unstd. Coeff.	Northridge (full) SE	Northridge (full) Std. Coeff
Full-time Employees (ln)	.27***	.04	.24	.15***	.03	.15	.16***	.03	.17
Wholesale or Retail	.41**	.13	.13	.57***	.13	.16	.54***	.13	.15
Finance, insurance, or real estate	.12	.20	.02	.62***	.16	.13	.57**	.17	.12
Services	.27*	.13	.09	.39**	.12	.12	.31*	.13	.10
Loss of Electricity	.40*	.19	.08	.88***	.12	.28	.85***	.13	.28
Loss of Telephones	.17	.13	.05	.27*	.12	.09	.19	.12	.06
Loss of Water	.57***	.11	.20	1.02***	.12	.27	.77***	.13	.20
Peak Ground Acceleration	---	---	---	---	---	---	1.62***	.25	.22
Year Built (1960-76)	---	---	---	---	---	---	.11	.11	.03
Year Built (Post-1976)	---	---	---	---	---	---	.22	.12	.07
N	725			852			719		
R^2	.14			.29			.33		
F-value	16.69***			48.20***			35.55***		

*$p<.05$ **$p<.01$ ***$p<.001$

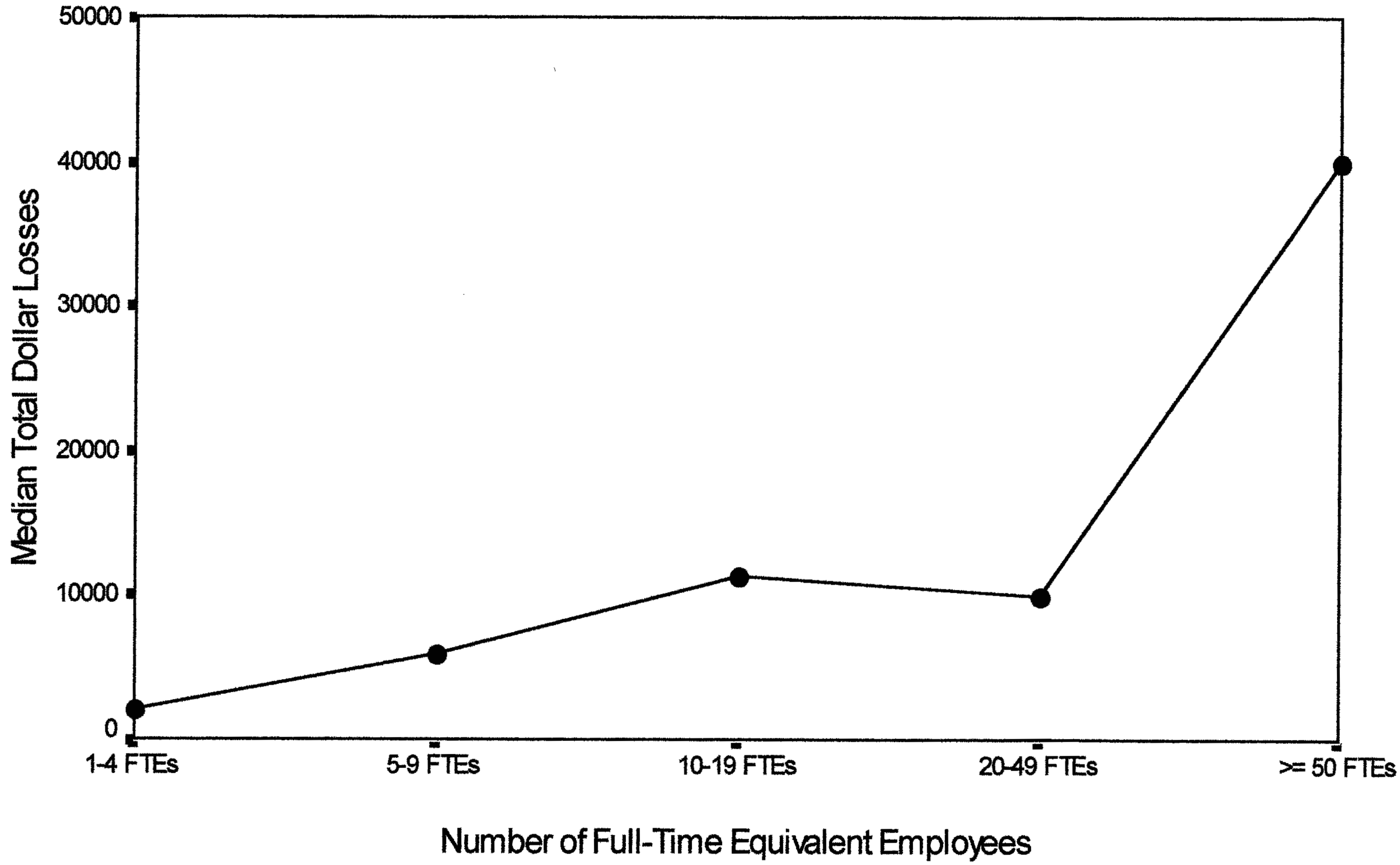

Figure 1: Median Total Dollar Losses by Number of Full-Time Equivalent Employees (Santa Cruz County)

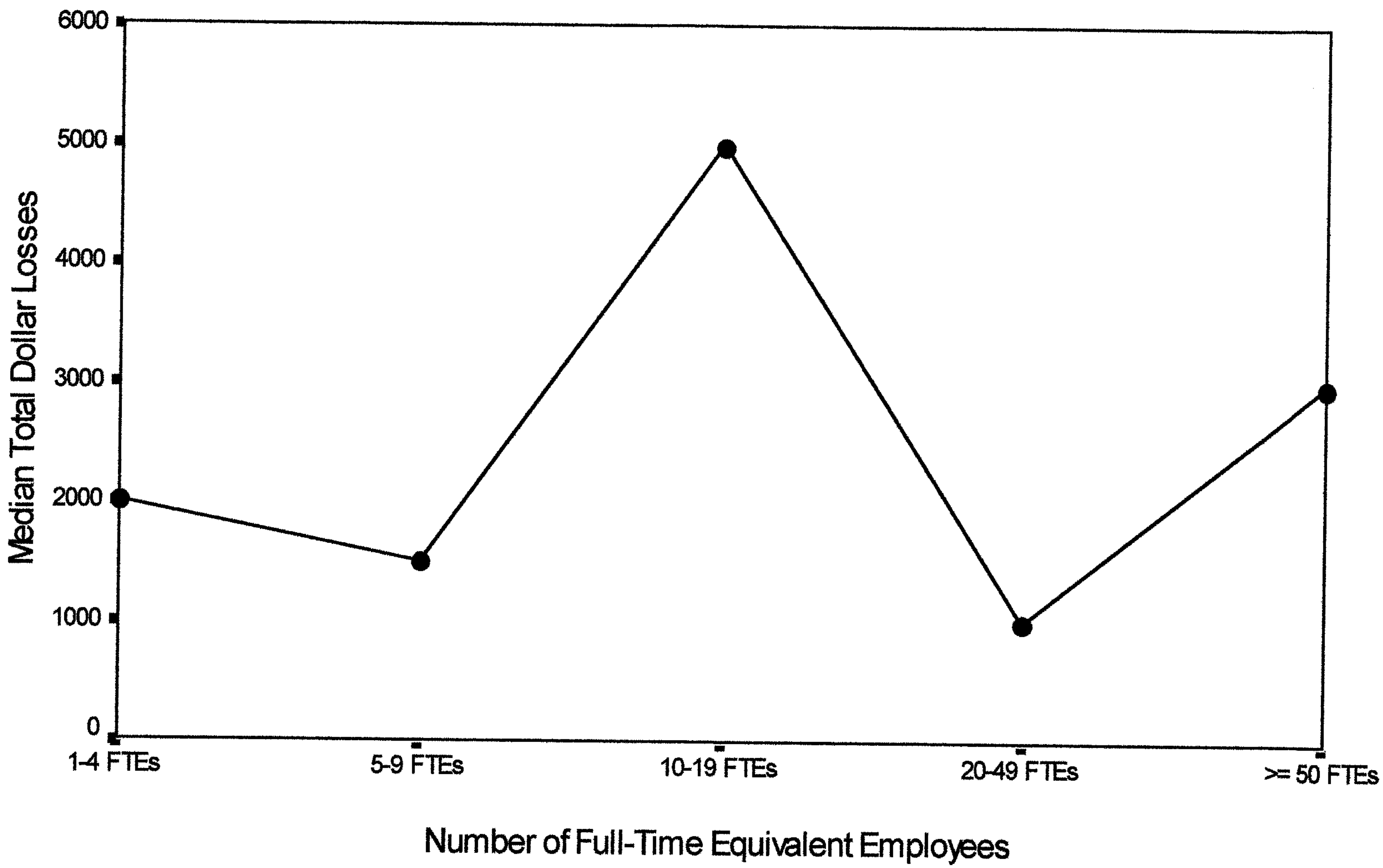

Figure 2: Median Total Dollar Losses by Number of Full-Time Equivalent Employees (Northridge)

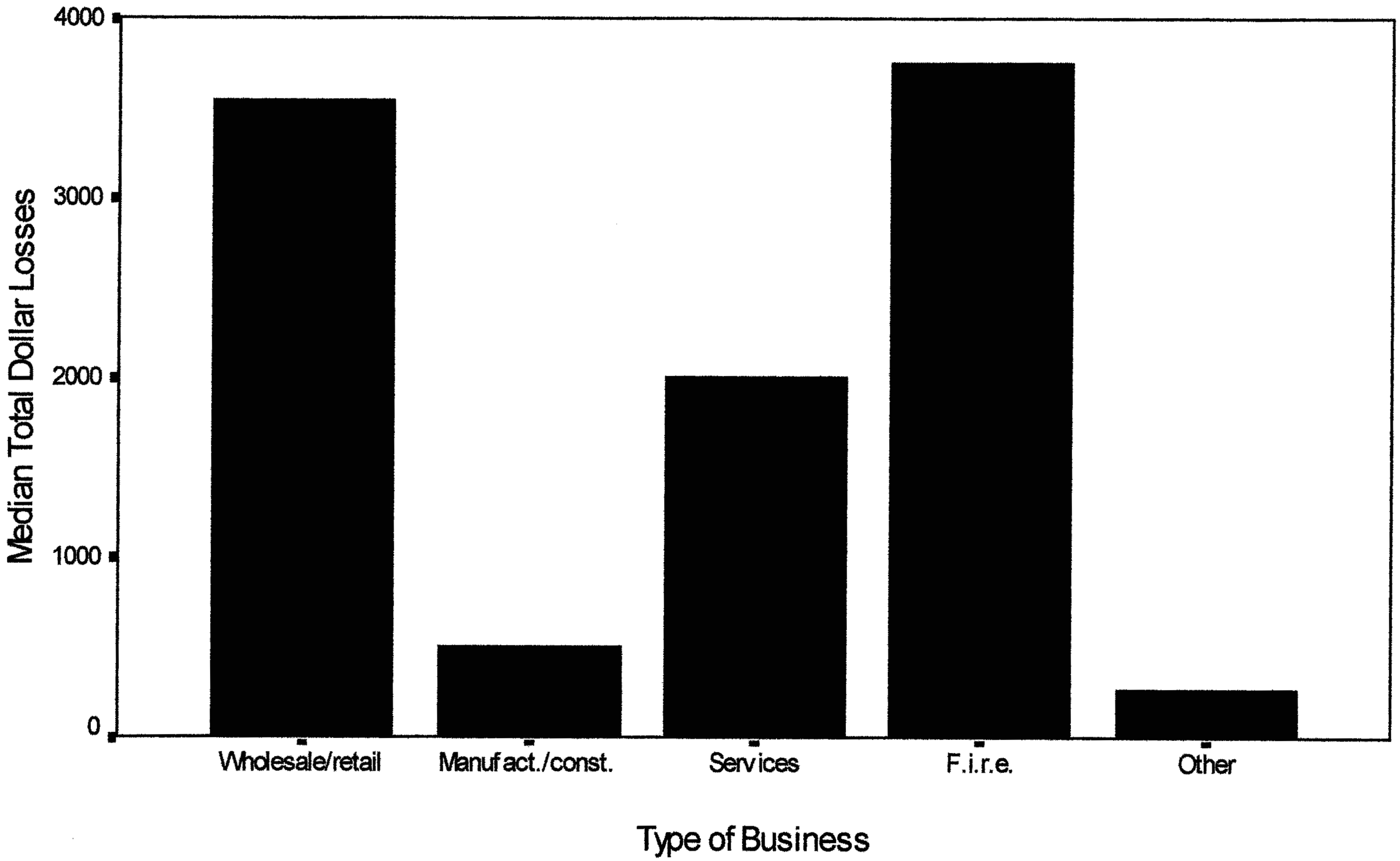

Figure 3: Median Total Dollar Losses by Type of Business (Northridge)

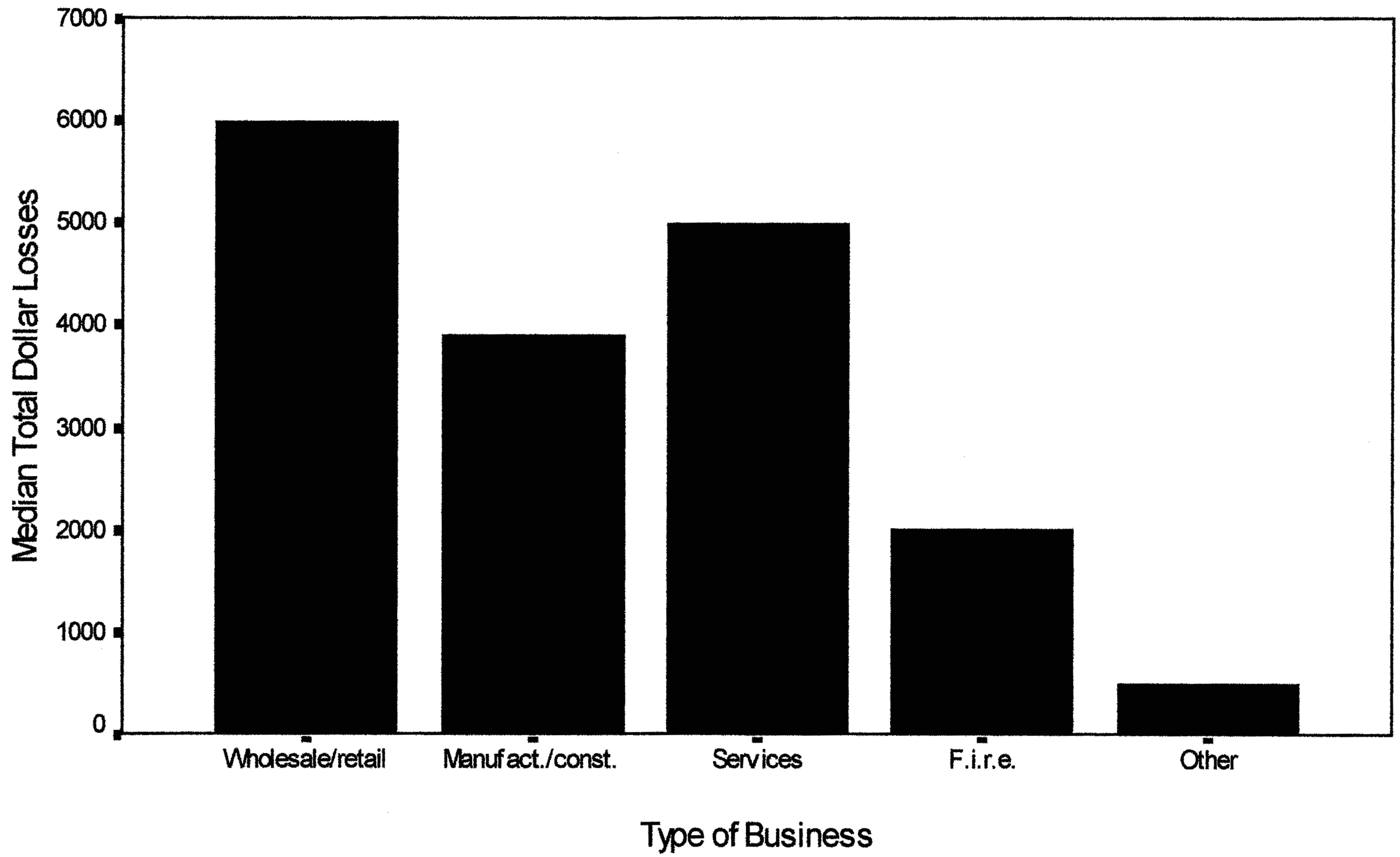

Figure 4: Median Total Dollar Losses by Type of Business (Santa Cruz County)

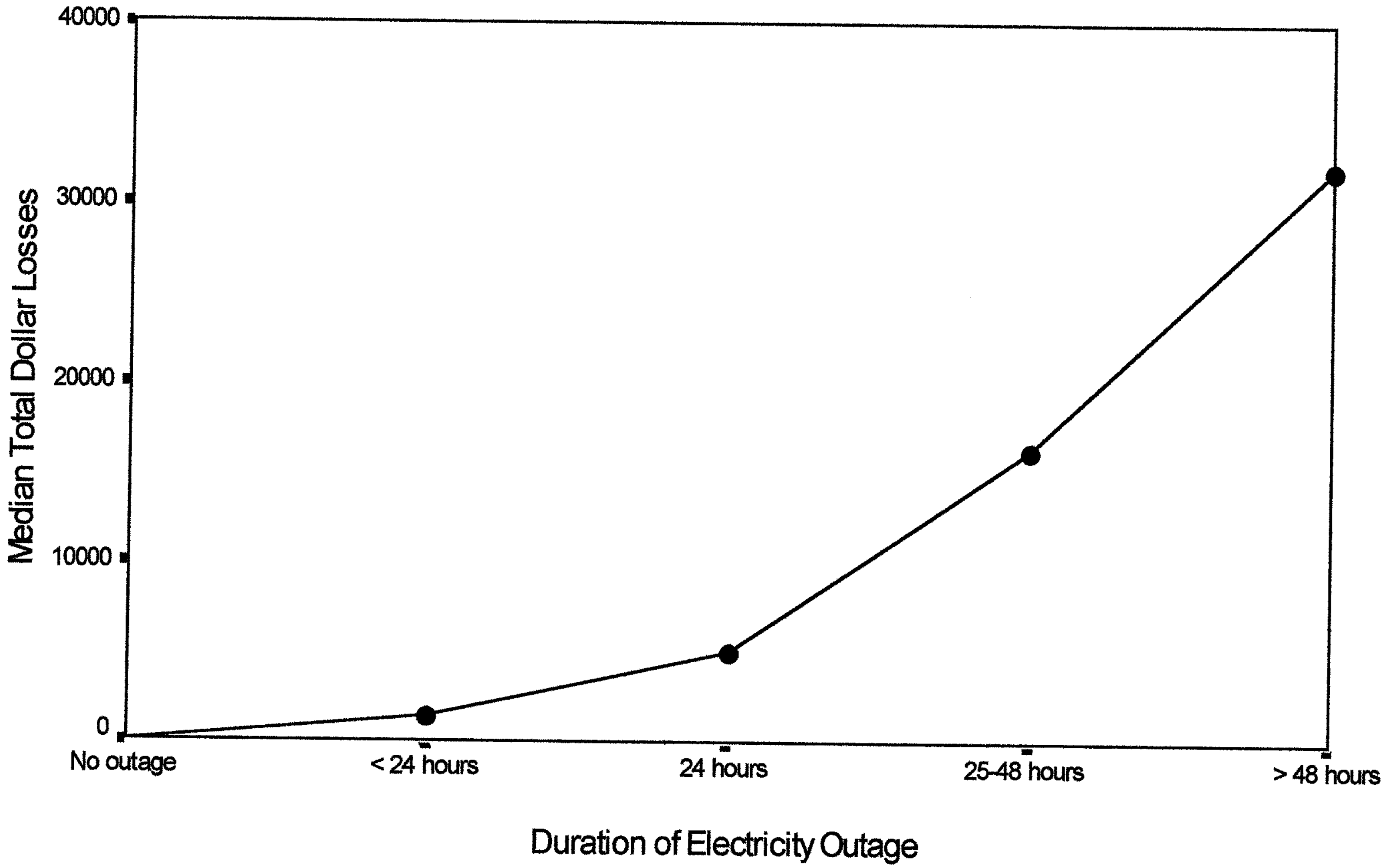

Figure 5: Median Total Dollar Losses by Duration of Electricity Outage (Northridge)

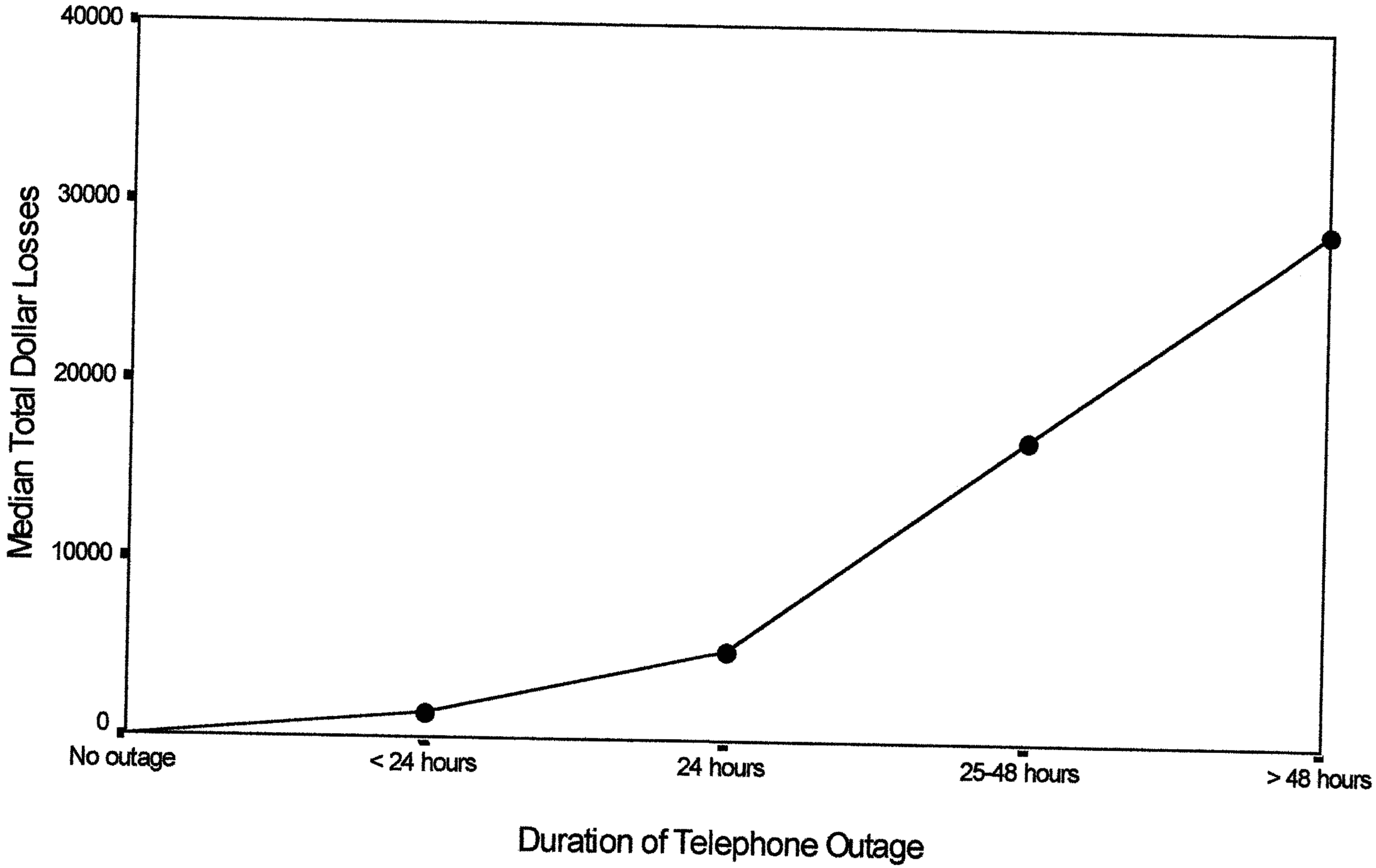

Figure 6: Median Total Dollar Losses by Duration of Telephone Outage (Northridge)

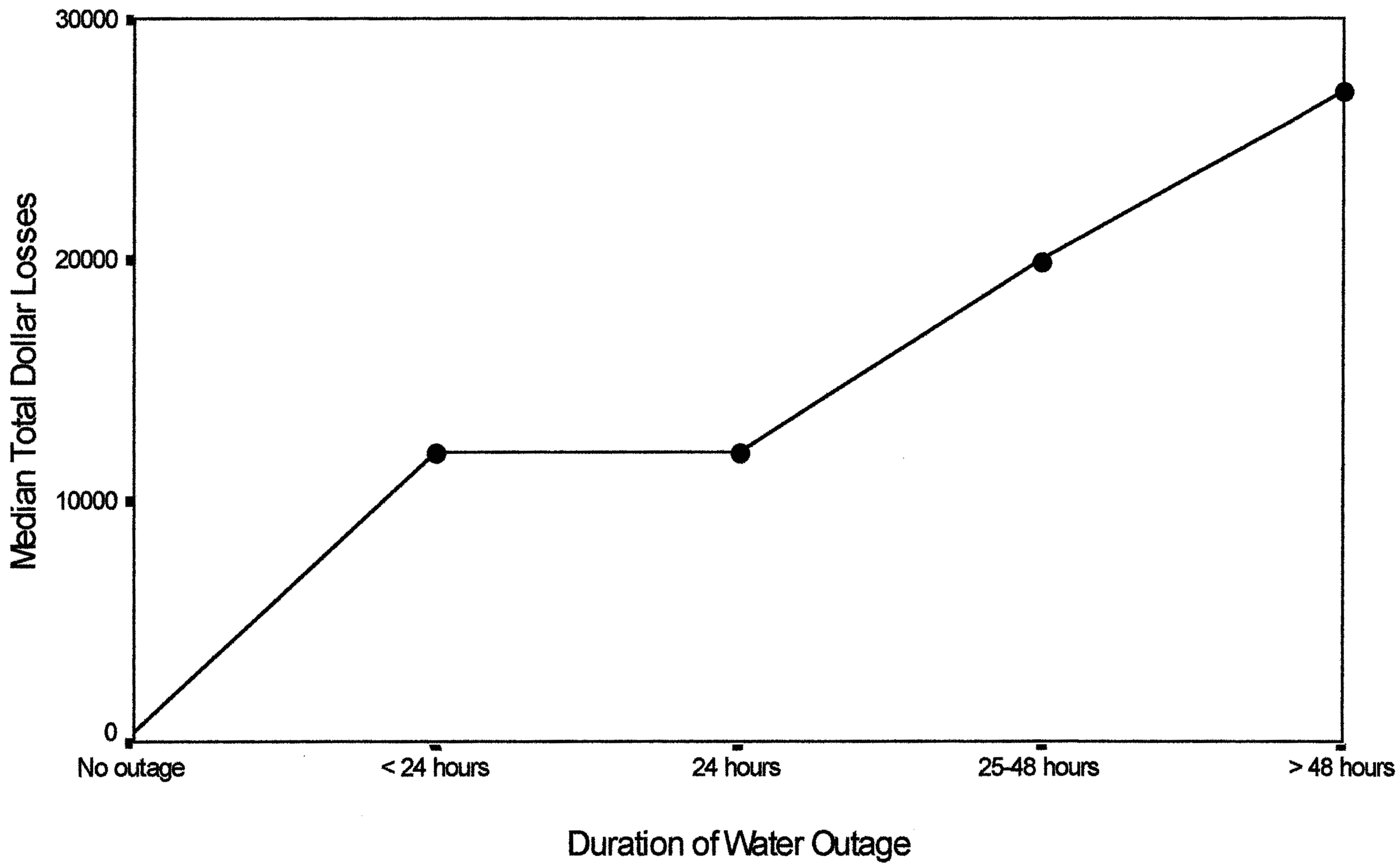

Figure 7: Median Total Dollar Losses by Duration of Water Outage (Northridge)

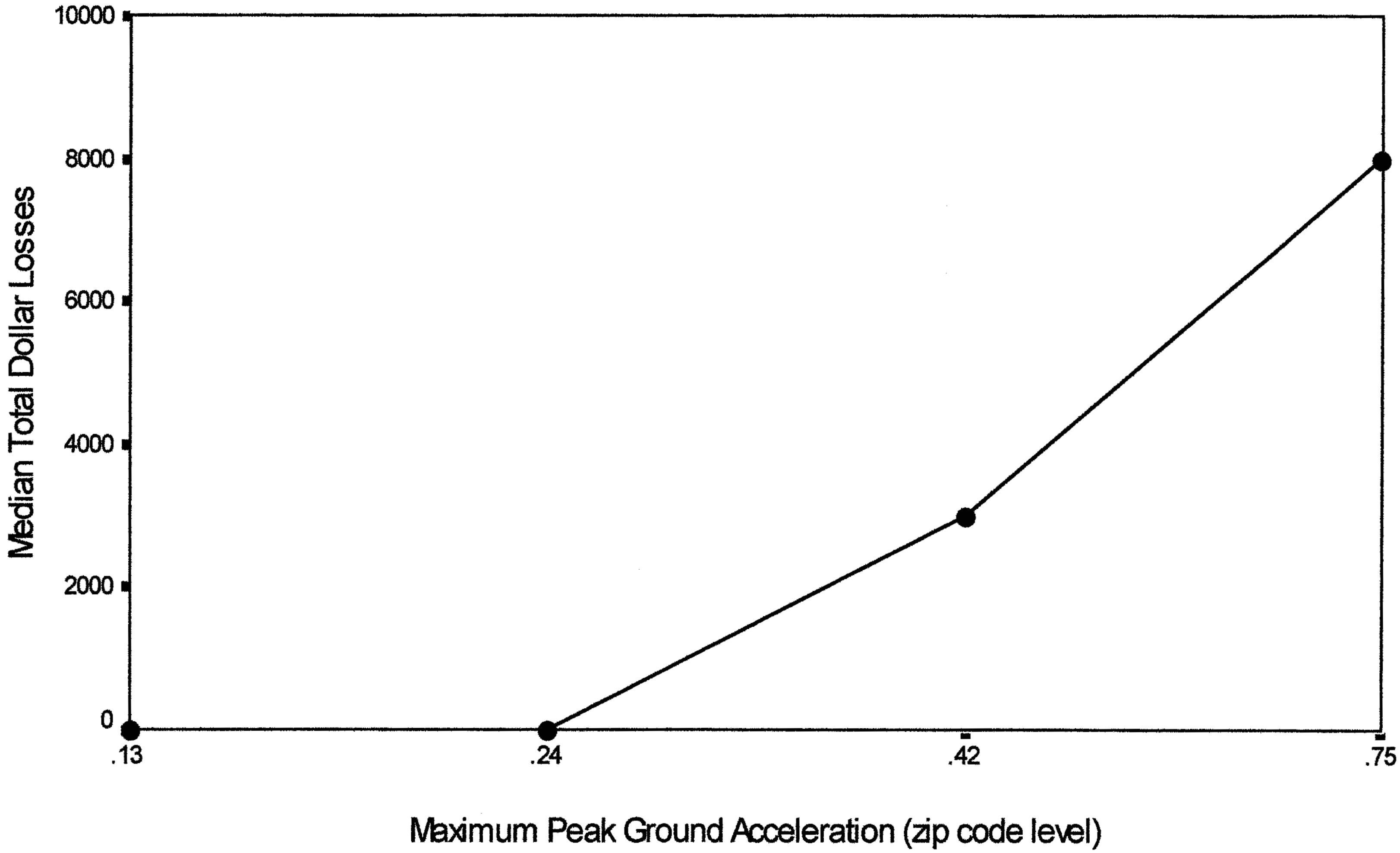

Figure 8: Median Total Dollar Losses by Maximum Peak Ground Acceleration (Northridge)

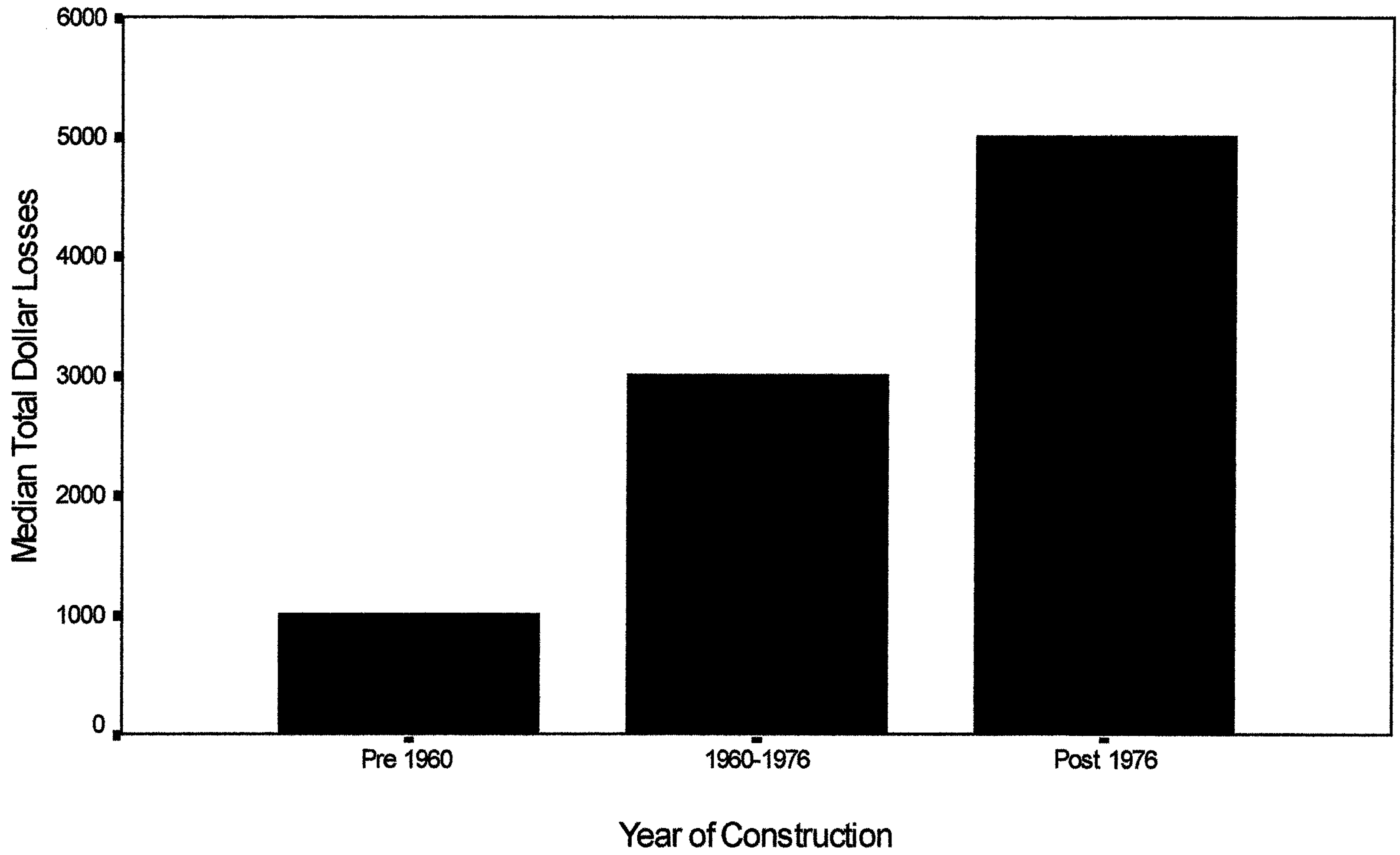

Figure 9: Median Total Dollar Losses by Year of Construction (Northridge)