



## **PREDICTING EARTHQUAKE PREPARATION: SMALL BUSINESS RESPONSES TO NISQUALLY**

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### **SUMMARY**

A large-sample survey of small business owners documented their experiences with the Puget Sound's February 2001 Nisqually earthquake. Nisqually was a large magnitude (6.8 Mw) quake but it was quite deep and so yielded relatively mild ground shaking. Compared with the Northridge earthquake, that had a similar moment magnitude number, injuries and damage from Nisqually were minor. Public policy makers were concerned that local residents may have grown more complacent about earthquake risks as a result of their experience with Nisqually. Our survey explores small business owners' risk perceptions and mitigation behaviors following the quake. Following Nisqually, most business owners said they were aware that the region is susceptible to far more serious seismic events. However, two-thirds reported that they concluded from Nisqually that they must be already well prepared for earthquakes since their firm had fared well in this one. Consistent with this attitudinal finding, only about one-third took steps after Nisqually to better prepare for future earthquakes. We examine several psychological (i.e., worry, individualism-collectivism), economic (i.e., revenues, losses) and seismic factors (i.e., shake) that predict which owners grew reassured and which grew more careful, which added mitigations following the quake and which did not.

### **INTRODUCTION**

The 2001 Nisqually earthquake was the first major earthquake in Washington State in 35 years and the largest in 50 years. Generating an estimated \$2 billion in total losses, it was the costliest natural disaster in the State's history. In this sense, it was an unusual event. In the geologic scheme of things, though, deep earthquakes like Nisqually are relatively common in Western Washington, occurring approximately twice in a lifetime. While these deep quakes are strong at their source, their force dissipates as it moves upward through miles of earth and rock so they do not yield devastating levels of surface shaking.

Two far less frequent but far more dangerous types of quake also occur in Western Washington. Shallow quakes, similar to the 1994 Northridge, California, earthquake, can occur along several faults in and around Seattle. In addition, devastating subduction zone quakes occur off the Washington-Oregon-

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California coast approximately once every 250-800 years. The region's last subduction quake was a devastating magnitude 8.5 or 9 in 1700. That quake sunk forests on the Oregon and Washington coasts, toppled homes on Vancouver Island, and generated a large tsunami that flooded and destroyed buildings and crop fields in Japan.

Learning from earthquakes, extrapolating from past experience to possible future events, is never simple since the probability, timing and local effects of future quakes are all highly uncertain. Learning from Nisqually was additionally complicated because its moment magnitude number was large (6.8  $M_w$ ) yet its surface motions and consequent damage were relatively mild. California's 1994 Northridge earthquake had a slightly lower moment magnitude number than Nisqually but was a shallow quake with significant aftershocks. The ground shaking, death, damage and destruction from Northridge were enormously worse than from Nisqually (see Table 1). There was concern in Washington that residents who focused on Nisqually's large magnitude number while experiencing little shake or damage might discount the potential dangers of future quakes. If residents overgeneralized, they might conclude they are well prepared for large earthquakes when, in fact, Nisqually was not the region's "big one."

Table 1: Comparison of Nisqually and Northridge earthquakes

	Nisqually	Northridge
Moment Magnitude	6.8 $M_w$	6.7 $M_w$
Ground Shake near Epicenter	Mercalli VII	Mercalli IX
Depth of Hypocenter	33 miles	11 miles
Largest Aftershock	3.4 $M_w$	5.9 $M_w$
Deaths	1	57
Insured Losses	\$305 million	\$15 billion
Estimated Total Losses	\$2 billion	\$40 billion

Source: Southern California Earthquake Center, University of Southern California, Instanet News, <http://www.scec.org/instanet/01news/feature01313.html>

We set out to identify the lessons small business owners drew from Nisqually, particularly what they concluded about earthquake risks and about preparing for future quakes. We surveyed a random sample of those members of the National Federation of Independent Business whose businesses were in locations affected by the earthquake. Four thousand surveys were mailed. Eight hundred thirty two useable surveys (21%) are included in the analysis below. In addition to questions about risk and mitigation, the survey also asked owners to report their direct and indirect earthquake losses and how these were financed. Meszaros and Fiegenger (2002) provides a complete report on small business losses from Nisqually.

## SAMPLE AND METHODS

A survey was mailed to four thousand randomly selected members of the National Federation of Independent Business in early winter 2001. Over 900 were completed and returned. A total of 832 valid responses from small businesses (average number of employees, 13) were used to construct a weighted, stratified profile of regional losses. Our complete report on losses in the region is available at: <http://peer.berkeley.edu/nisqually/nisquallysmallbusiness.pdf>. When we discuss risk perceptions and mitigation choices following the quake, we rely on only the survey responses provided by CEOs as their attitudes are most likely to be determinate of organizational choices (n=571).

## OVERALL RISK AND MITIGATION PERCEPTIONS

Most respondents indicated that they recognize that the Puget Sound region is susceptible to far more serious earthquakes than Nisqually. As shown in Table 2, 43% judged Nisqually not seriously harmful. Intriguingly, 68% assessed the probability that the region will suffer a catastrophic earthquake in their lifetime as higher than the midpoint on a 7-point scale ranging from not-at-all-likely to extremely-likely. They believe, in other words, that it is more likely than not that they will live to see a catastrophic quake. Most (67%) indicated, though, that either they grew less worried or their level of worry about earthquakes was unchanged as a result of their experience with Nisqually.

Table 2: Perceived earthquake risks

	1-3 (low estimate)	4 (midpoint)	5-7 (high estimate)
Thinking about the overall effect of the Nisqually earthquake on this region, how serious do you consider it in terms of harm to people?..... Scale: 1=not at all serious, 7=extremely serious	43%	28%	29%
How likely do you think it is that this region will experience an earthquake causing catastrophic levels of harm to people during your lifetime?..... Scale: 1=not at all likely, 7=extremely likely	16%	16%	68%
AFTER the Nisqually earthquake, are you personally MORE worried or LESS worried about future earthquakes?..... Scale: 1=far less worried, 4=no change, 7=far more worried	12%	55%	33%

Even though two-thirds of the respondents consider a catastrophic earthquake to be more likely than not in their lifetime, two-thirds also concluded that their firms must be already well prepared for earthquakes since their firm fared well in Nisqually (see Table 3). Nisqually may indeed have precipitated some comfort with earthquake risks.

Table 3: Judgments about earthquake preparedness

Which of the following two statements comes closest to <u>your personal</u> reaction to this earthquake?	
Our organization seems well prepared for earthquakes since we fared pretty well.....	67%
Our organization needs to get better prepared since more serious earthquakes can happen..	33%

## PREDICTING MITIGATION

All survey respondents reported which, if any, of 17 disaster preparation activities their firms undertook before and after the earthquake. The list of mitigation activities (see Table 4) was based on several

previous studies of natural hazard mitigation. Most of the mitigations are helpful for multiple types of disaster, not earthquakes alone.

Table 4: Types of mitigation

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Store First Aid supplies in building
Store computer data files (backups) off-site
Purchase business interruption insurance
Train employees in emergency response
Develop a disaster plan
Redundancy (e.g., backup machines, extra inventory, emergency generator, etc.)
Purchase earthquake insurance
Stockpile emergency supplies (e.g., spare parts, fuel, water, food, etc.)
Non-structural mitigation (e.g., strapping shelves & equipment)
Store copies of critical contracts and documents off-site
Practice a disaster plan
Structural mitigation (e.g., reinforcing, bracing, bolting, etc., of building)
Have engineer perform structural assessment of building
Arrange with other organizations for mutual aid (e.g., sharing personnel, facilities, etc.)
Seek additional information about disaster planning & recovery
Increase % of supplies from non-local suppliers (i.e., less dependent on local suppliers)
Increase % of sales to non-local customers (i.e., less dependent on local customers)

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Overall, the companies in our study added, on average, approximately one mitigation after the quake. It was not the case that most firms added some protection or other, however. Instead, a little more than a third of firms added several mitigations (on average, each added 2.6) while the others made no new effort (see Table 5).

Table 5: Pattern of mitigations

	Mitigations after Nisqually Earthquake
% of firms adding mitigations.....	33%
Average no. of measures per mitigating firm.....	2.6

We set out to identify factors that predicted which firms initiated one or more new mitigation activities after the earthquake versus those who did not. We examined several potential organizational, experiential and psychological predictors. The analysis method used was a step-wise logistic regression analysis. The variables examined, the order in which they were included in the regression analysis, and the levels of predictive statistical significance achieved are outlined in Table 6. Complete results and a more comprehensive discussion of variables are available from the authors.

Table 6: Results of logistic regression analysis: predicting new mitigation activity

Step	Variable Type	Variables	Sign	Significance
1	ORGANIZATIONAL	Industry		n.s.
		Organizational age		n.s.
		Organizational size		n.s.
2	PRE-DISASTER EXPERIENCE	Previous natural disaster, accident or fire	+	n.s.
		Mitigation prior to Nisqually		
3	EXPERIENCE IN QUAKE	Disruption	+	p<.001
		Direct losses	+	p<.01
		Shake intensity (modified mercalli scale)		n.s.
4	PSYCHOLOGICAL/COGNITIVE	Individualism	-	p<.05
		Worry	+	p<.001
		Perceived risk		n.s.

n.s. = not significant

Firms that had undertaken some mitigations previous to the earthquake (i.e., *Mitigation prior to Nisqually*) were significantly more likely to add additional mitigations following. In short, the careful grew more careful; they drew the conclusion that more care was in order no matter whether their shake experience or whether their losses were small or large.

*Worry* was also a highly significant predictor of mitigation. Those who were more worried about earthquakes following Nisqually were significantly more likely to invest in mitigations. This finding is consistent with several previous studies of “worry” or “concern” as a predictor of mitigation (i.e., Baron et al. 2000; Palm and Carroll 1998).

The worry effect is particularly interesting in light of the fact that respondents’ estimates of the likelihood of future catastrophic earthquakes (i.e., *Perceived risk*) was NOT a significant predictor of mitigation. This most purely “rational” assessment of earthquake risk did not predict mitigation whereas the semi-emotional, semi-cognitive “worry” variable was unquestionably important. To better understand mitigation, we need to better understand worry.

Respondents’ *individualism* was significantly but negatively related to mitigation. The more strongly individualistic the respondent, the *less* likely that the firm undertook mitigations. Previous research has found that highly individualistic Americans are less willing to invest in earthquake mitigation than less individualistic Japanese (Palm and Carroll 1998). Perhaps individualists place more value on the benefits they could get by using their resources for something other than mitigation or perhaps they are more likely to expect others will bail them out if a bad event happens. This is another area that deserves further research scrutiny.

Finally, the degree of disruption and direct losses a firm experienced were significant predictors of post-quake mitigation. From this we might conclude that owners considered their experience in this quake to be a good indicator of experience in future quakes. This is in part a sensible response; ground shake experience in the next Nisqually-like quake is likely to resemble ground shake in 2001. It is not, however, a good conclusion for other future quakes. Shallow and subduction zone quakes will yield very different experiences. Businesses and buildings that experienced little difficulty with Nisqually may experience far more serious motion in these sorts of events.

## CONCLUSIONS

The Nisqually earthquake was not a blanket wake-up call to the region. It was a wake-up call to those with the greatest disruption and damage. And to the worriers. And to the careful.

Probably the most striking finding from this survey is how the lessons drawn from the quake differed based on psychological and emotional factors like worry and individualism more than on more rational or objective factors like perceived risk or experienced shake. Those responsible for disaster prevention and preparedness need better understanding of how these extra-rational forces affect willingness to invest in preparation for rare disasters.

## REFERENCES

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