

THE EARTHQUAKE INSURANCE PROTECTION GAP: A TALE OF TWO COUNTRIES

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IMPORTANCE The insurance protection gap, the portion of total economic losses generated by a loss event that is not covered by insurance, is an issue that concerns regulators, insurers, taxpayers and many others worldwide.

Globally, this gap came in at 161 billion USD in 2019 for all perils. For the earthquake peril alone, over the past decade (2010-2019) only 102 billion USD of 535 billion USD in losses were covered by insurance, not quite one-fifth of all losses. The literature is clear that countries where market penetration (or take up) of insurance is high are more resilient and bounce back considerably faster after a catastrophic loss than places where take up of insurance is low.

OBJECTIVES Our study provides an analysis into why market penetration of earthquake insurance for personal properties is considerably higher in the Lower Mainland of British Columbia (B.C.) as compared to western Washington state (WA) (~60 percent versus ~14 percent) even though both places are subject to similar and significant earthquake risk. We look at several potential influencers into earthquake insurance purchasing decisions, including socioeconomic factors (such as age, education, income), perceptions of seismic risk and expectation of government bailout, and issues pertaining to the earthquake insurance product itself (such as cost, product design and availability). We conclude with recommendations for policymakers regarding barriers and considerations for improving market penetration of earthquake insurance in WA that may also be relevant in other locations in the U.S. that also face natural catastrophe risk.

FINDINGS Several theories exist as to why take up of earthquake insurance in earthquake prone countries tends to be low considering the significant risk. These range from unattractiveness of the policy cost and design, household income constraints, limited overall awareness of earthquake risk, lack of understanding of insurance coverage, the expectation that the government will compensate losses, and lack of availability of coverage. Our analysis finds all but one minor difference in these factors and these do not explain the significant difference in earthquake insurance take-up rates in B.C. over WA. The only significant difference found between the two locales is the broader availability of disaster assistance in WA over B.C.. The B.C. government has publicly stated that it will not pay assistance for earthquake damage due to the availability of private insurance.

We conjecture that this and issues centering around national culture (i.e. Americans are fundamentally different than Canadians in that they do not respond well to being told what to do by authorities) are the two main reasons why earthquake insurance take up rates are so low in WA. We do caution, however, that primary survey data related to all noted factors be collected and analyzed in more depth.

CONCLUSION & RELEVANCE Given the increase in economic losses due to natural catastrophes, it is essential to decrease the insurance protection gap. When losses are insured, individuals, businesses and other institutions do not need to fund repairs, replace damaged/destroyed assets and replace lost income ex post. Reducing the protection gap reduces the burden on taxpayers and promotes societal resiliency.

While the protection gap exists for many reasons, potential solutions have been explored worldwide to reduce the gap. For example, mortgage lenders could require or governments could mandate the purchase of insurance. Changes in product design, by bundling all perils into the basic insurance policy or by changing policy duration, or providing "insurance stamps" to high risk but low income households could also incent more homeowners to purchase earthquake insurance. There may be a role for governments to act as insurers, provide a liquidity or solvency backstop to insurers or offer coverage through property taxes.

Our findings go beyond the issue of seismic risk and are relevant when considering the impact of climate change, as the phenomenon will increase weather-related risks in many geographic locations in the United States and elsewhere. This increased risk will require both insurers and governments to take steps to ensure that adequate protection against catastrophic losses is present.

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The Earthquake Insurance Protection Gap: A Tale of Two Countries

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Abstract

In this paper, we examine reasons why take-up rates for earthquake insurance are significantly higher in the Lower Mainland of British Columbia than in western Washington state even though earthquake risk is largely the same. Achieving and maintaining high insurance take-up rates for catastrophic events matters because this can play an important role in improving the resiliency of communities. After exploring several factors known to influence the supply and demand of insurance for high-severity but low-frequency events, we find only two key differences: 1) disaster assistance is more readily available in the U.S.; and 2) Canadians are more willing to purchase earthquake insurance when they are told they should. We conjecture that many policy options to increase insurance take-up rates, such as product redesign or cross subsidization, are not likely to be effective in Washington. Making insurance mandatory—either via legislation, making earthquake coverage a prerequisite for a mortgage or embedding it into property taxes—might be the only viable way to increase take-up rates, although these options may be politically difficult to enact.

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Introduction

The insurance protection gap, defined as the portion of total economic losses not covered by public or private insurance, is an issue that concerns regulators and insurers worldwide and is a problem that exists in frontier, emerging and developed nations. During the past decade (2010–2019) alone, global direct economic losses from the earthquake peril aggregated to US\$535 billion. Yet only US\$102 billion—or 19%—was covered by insurance. This translates to a “protection gap” of 81%.¹ A well-functioning insurance market is essential in building resilient economies. Munich Re (2017) observed, “Recent studies show that if you take two countries with identical per-capita income, the country with higher insurance cover will be more resilient to natural disasters.” Adequate insurance protection motivates both ex ante mitigation (by correctly pricing risk) and provides for ex post indemnification so that impacted communities can recover quickly. As noted by the Organisation for Economic Co-operation and Development (OECD), the insurance protection gap is most severe for earthquake and flood losses as “earthquake losses (along with flood losses) are the least insured among disaster perils.” (OECD, 2018, p 61).

The societal drivers of the protection gap for personal lines coverages differ according to the economic development of a nation.² On the supply side, insurers may not be willing to offer coverage. Insuring low-probability, high-severity events is costly for insurance companies. Kleffner and Doherty (1996) found that insurer characteristics, such as ownership structure, distribution mechanisms and overall leverage, affect the amount of risk insurers are willing to carry. The ability of insurers to share earthquake risk with international reinsurers and financial markets and the presence of government backstops will also affect the willingness of insurers to offer earthquake coverage.

In mature markets, on the demand side, Kunreuther and Michel-Kerjan (2009), Klein (2018), and Schanz (2018), among others, suggest that product appeal (pricing and structure of the policy including limits, deductibles and other means of sharing the risk) and behavioral biases (including myopia, risk perception and risk aversion) drive the insurance purchasing decision of individuals and households. Risk perception is influenced by many factors, including recallability of recent events, general public awareness, and messaging of urgency and importance from external sources. Other related reasons why households underinsure include household wealth constraints and an expectation of government disaster assistance after a large

1. The global protection gap for all natural disasters in 2019 was US\$161 billion, or 69%, which was significantly below the 10-year average of US\$210 billion (Aon, 2020). This drop in 2019 was not a result of increased insurance penetration, but due to catastrophe events occurring in areas with a more mature insurance market and higher insurance take-up. Economic (insured) losses arising from earthquakes in 2019 was only US\$3 billion.

2. Our focus here is the individual homeowner’s role in reducing the protection gap. We acknowledge that, especially for developed nations, the main driver of the protection gap is the fact that most public infrastructure is not insured.

natural catastrophe. As opposed to spending funds on insurance, households could choose instead to use these funds to undertake mitigation activities. There is inconclusive evidence as to whether other demographic factors, such as the age and education level of the householder, influence the decision to purchase insurance.

In this paper, we examine the above listed factors using available data on the take-up rates of earthquake insurance in the Pacific Northwest (and, in particular, western Washington state and the Lower Mainland in British Columbia). Both western Washington and the Lower Mainland are situated on the Cascadia subduction zone, and they face similar and significant earthquake risk.³ Despite this risk, neither jurisdiction mandates the purchase of earthquake coverage. It is also not a prerequisite for obtaining a mortgage.⁴ However, the take-up rate for earthquake insurance in the Lower Mainland exceeds 60% (Goda et al., 2020) compared to roughly 14% of residential properties west of the Cascades in Washington (Kreidler, 2018).

Figure 1 is a map of the Pacific Northwest extracted from the Global Earthquake Model (GEM), and it shows the seismic risk of the region. The map displays the peak ground acceleration (PGA) with a 10% probability of being exceeded in 50 years. The orange locations are the most seismically at risk, followed by yellow and then light green. As can be seen in the map, areas immediately west of Seattle and north of Olympia extending up into Vancouver Island have greater seismic risk than Vancouver and coastal Washington. Up-to-date information on the most recent earthquake events can also be found on the Pacific Northwest Seismic Network's (PNSN's) website at <https://pnsn.org/earthquakes/recent>. The OECD (2018, p. 37) cites a Bank of England report that finds that a magnitude 9 (M9) Cascadia earthquake "affecting the Northwestern United States and Western Canada would cause an estimated USD 174 billion to USD 186 billion in losses."

There are small differences between the two jurisdictions in terms of the pricing and structure of earthquake insurance, household income and demographics, and community awareness of earthquake risk. If risk perception is heightened by recent catastrophic events, then we would expect higher take-up rates in western Washington as it has had more recent significant earthquakes than the Lower Mainland. We propose two fundamental reasons why take-up rates are substantially higher in the Lower Mainland. The government of British Columbia has flatly stated that there would be no post-disaster relief available to households after an earthquake, whereas in the U.S., Kousky et al. (2018) note that the Federal Emergency Management Agency (FEMA) routinely offers financial aid after a disaster.⁵ The second reason is one of national culture: Canadians purchase

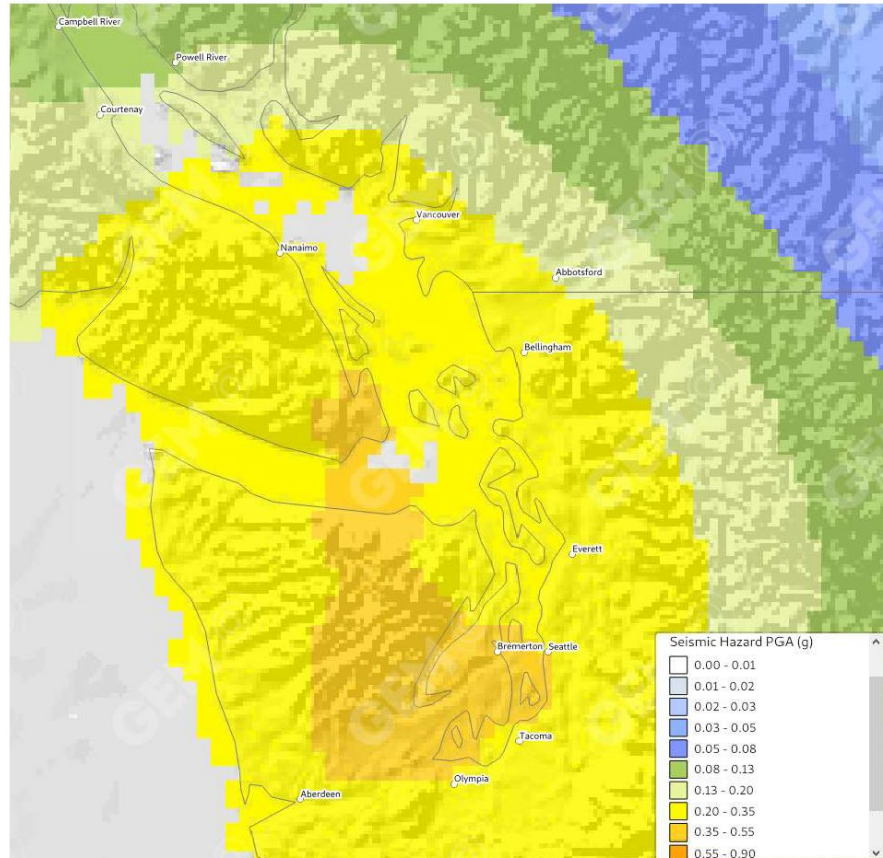
3. A summary of the risk is detailed in Kathryn Schulz's (2015) Pulitzer Prize winning article, "The Really Big One."

4. Some lenders in Washington require the purchase of flood insurance depending on the location of the risk. And some small non-diversified lenders in British Columbia (local credit unions) require the purchase of earthquake insurance depending on the location. But industry professionals tell us that this is a very small portion of the market.

5. In Canada, governmental disaster assistance for homeowners is only available for losses not covered by insurance. This is typically overland flood where that coverage is not available and

earthquake insurance because they are told it is a prudent thing to do, whereas Adams (2014) and Thomas and Biette (2014) suggest that Americans distrust what is told to them by their elected officials.

Figure 1:
Map of Seismic Hazard for Pacific Northwest



Source: GEM Global Seismic Hazard Map (Pagani et al., 2018)

We provide some policy options for improving the take-up of optional earthquake insurance coverage. Whereas optional insurance take-up rates can typically be increased by raising the community's awareness of risk and by improving affordability or coverage provisions of the policy, we suspect these options would not work in western Washington. Take-up rates may be improved if

additional living expenses for wildfire loss that exceeds policy limits when civil authority prohibits access to premises.

earthquake insurance is made compulsory or if ex post-disaster assistance can be modified or eliminated. However, we acknowledge that these may not be economically or politically viable options. One final option would be to bundle coverage with property taxes (like Israel's Property Tax and Compensation Fund). This would provide funds for the state government to purchase insurance or insurance linked securities (ILS) or create an earthquake reserve fund. One benefit of this policy is that it can also be used to improve mitigation and/or reduce the number of homes in higher risk areas.

This paper proceeds as follows. We first define the factors that are conjectured to affect a household's decision to purchase earthquake coverage, taking care to highlight similarities and differences between western Washington and the Lower Mainland. Based on this analysis, we then discuss several policy options that could be implemented to improve take-up rates of earthquake insurance in western Washington. We conclude with a discussion that influencing factors and possible policy options for improving take-up rates for earthquake insurance may be applicable more generally to most catastrophic losses faced by communities in the U.S.

Factors Influencing the Decision to Sell Earthquake Insurance

One reason that take-up rates of earthquake coverage is low could be a lack of insurers offering coverage. Although some companies bundle optional earthquake coverage with coverage for other natural disasters, in Canada and the U.S. (as well as Switzerland), earthquake coverage is not combined with other natural disasters (OECD, 2018). Earthquake insurance is typically sold as an endorsement to existing homeowners insurance coverage, although some companies may sell it as a stand-alone product.

There is great uncertainty (and, therefore, risk) in offering insurance for low-probability, high-severity events. Kleffner and Doherty (1996) examined the relationship between insurer characteristics and the firm's maximum possible earthquake exposure in California. They found that highly levered firms assumed less earthquake risk, as did mutual insurers, agency writers and firms that were relatively undiversified geographically. These firms had a higher cost of risk bearing and, hence, underwrote less earthquake insurance.

Furthermore, the supply of homeowners insurance generally is affected by previous catastrophes within a jurisdiction. Born and Klimaszewski-Blettner (2013) in a study of U.S. insurers found a positive relationship between large natural disasters (of all types) and the probability of a subsequent exit or reduction in the amount of business for companies that wrote homeowners coverage within the afflicted state. State-level regulations could also affect the supply of insurance. Firms were more likely to reduce the amount of business written or exit a state after a catastrophic loss if the state had stringent rate regulations. The likelihood of

insurers exiting a state or reducing the amount of business written also increased if states enacted temporary bans on insurers cancelling business after a catastrophic event.

The availability of reinsurance, market-based protection such as catastrophe bonds or a government backstop would also affect insurers' willingness to offer earthquake coverage. In particular, the OECD (2018, p. 12) notes, "Government involvement is key in supporting the insurability of earthquake risk." Canada is the only country that does not have a government mechanism to backstop the insurance sector, as noted by Le Pan (2016) and Kelly, Kleffner and Kelly (2020). The Insurance Bureau of Canada (IBC) and the industry's guaranty fund, the Property and Casualty Insurance Compensation Corporation (PACICC), have put proposals in front of the Ministry of Finance to create a government backstop for catastrophic losses (PACICC, 2020). A similar situation exists in Washington: Although government backstops exist for some jurisdictions and some perils in the U.S., there is no government backstop for earthquake risk in Washington.

Despite the lack of backstop, as well as the riskiness of providing earthquake coverage, there does not appear to be a shortage of insurers offering coverage in the two jurisdictions. Unlike California, in which there is a legal obligation for insurers to offer earthquake insurance to those who purchase homeowners insurance, a similar law does not exist in Washington.⁶ Regardless, in Washington, there are approximately 110 authorized companies, with 60 offering earthquake coverage.⁷ However, for companies that offer personal property insurance, Kreidler (2018) calculated that only 16% of insurers did not offer earthquake coverage. Roughly five of these companies offer earthquake coverage as a stand-alone policy, and the remaining firms offer it as an endorsement. Kreidler (2018) noted that two companies have more than half the exposure in the state, and the average coverage value matches the average value across the state. An additional four companies specialize in high-value properties. In Canada, 58 insurers report positive direct written premiums for homeowners insurance in British Columbia, and, according to the IBC, essentially all of them offer earthquake insurance.⁸

Table 1 provides a brief overview of the characteristics of insurers offering earthquake insurance in the two jurisdictions in 2017. We define a firm as a personal lines underwriter if at least 50% of the countrywide net premiums written are for personal property and personal auto insurance. The percentage of premiums written in each jurisdiction is calculated as the total net premiums written in the jurisdiction divided by total premiums written nationwide. Leverage is defined as total liabilities divided by total assets, and size is measured by total firm assets.

In both jurisdictions, firms that offer earthquake coverage are more likely to be stock insurers and belong to a group. There is no statistical difference in the size of

6. Insurers in California have the option to underwrite coverage as an endorsement or stand-alone policy or offer coverage through the California Earthquake Authority (CEA).

7. Private communication with Washington State Office of the Insurance Commissioner.

8. However, according to Insurance Business Canada, only three insurers place no restrictions on the amount of policies underwritten in high risk areas (<https://www.insurancebusinessmag.com/ca/news/catastrophe/aviva-canada-embeds-earthquake-coverage-in-all-bc-policies-97789.aspx>).

insurers offering earthquake coverage in Washington and British Columbia. However, Canadian insurers have, on average, a bigger stake in British Columbia than American insurers have in Washington. In Canada, there are four insurers that write more than 70% of their premiums in British Columbia, and all remaining insurers write less than 25% of their premiums in British Columbia. In Washington, one insurer writes only in that state, three more insurers write between 40% and 55% of their premiums in the state, and all remaining insurers write less than 8% of their business in the state. Canadian firms are also significantly more levered than their American counterparts.

Table 1:
Characteristics of Firms Offering Earthquake Coverage in WA Washington and B.C. British Columbia⁹

	Washington State	British Columbia
Percentage direct writers	N/A	32.76%
Percentage mutual insurers	9.52%	15.52%
Percentage group members	95.24%*	67.24%*
Percentage personal lines writer	25.00%*	62.07%*
Average percentage of premiums written in jurisdiction	6.27%*	14.99%*
Average leverage	57.19%*	69.75%*
Average size (assets)	US\$3,978,760,883	CA\$2,013,384,983 (US\$1,530,172,587) ¹⁰

* Denotes statistically significant differences at 1% level

From Kleffner and Doherty (1996), based on the characteristics of insurers writing earthquake insurance in Washington or British Columbia, there should be greater availability of coverage in Washington compared to British Columbia. Insurers in Washington are more geographically diverse, have greater access to capital markets and are less levered. Therefore, it does not appear that the lack of earthquake insurance penetration in Washington state is due to supply side frictions.

9. Entries in the table are not weighted by amount of earthquake insurance written as we do not have these amounts.

10. In 2019, the exchange rate was CA\$1 = US\$0.76. However, over the same period of time, the purchasing parity power was CA\$1 = US\$0.83 for all goods and services and CA\$1 = US\$0.77 for goods alone (<https://www150.statcan.gc.ca/n1/daily-quotidien/200728/dq200728b-eng.htm>). Since the purchasing parity power is almost the same as the exchange rate, this implies that what can be bought with \$1 in either currency is the same.

Factors Influencing the Decision to Purchase Earthquake Insurance

Here we provide a further discussion on some of the key factors that influence a household's decision to purchase earthquake insurance, highlighting key differences and similarities between western Washington and the Lower Mainland.

Price and Design of Earthquake Insurance Coverage

Because earthquake insurance is typically purchased as an endorsement to standard homeowners insurance coverage, before discussing the price and design of earthquake insurance coverage, it is important to understand differences in the design and price of standard homeowners insurance coverage between the U.S. and Canada.

Our primary observation is that there is very little (if any) difference between the standard homeowners insurance coverage in the U.S. and Canada. The IBC and the Insurance Services Office (ISO) in the U.S. provide model wordings for homeowners insurance policies, and we summarize the key policy provisions in Appendix A. The policy provisions are essentially the same, and indeed in some sections, policy wordings are identical. In both jurisdictions, the comprehensive (Canada) and the equivalent HO-3 (U.S.) are the most popular policies. Industry professionals in Canada tell us that roughly 80% of homeowners purchase this policy in British Columbia, and according to the National Association of Insurance Commissioners (NAIC) (2019), 75.7% of owner-occupied dwellings in Washington purchase an HO-3 policy. With regards to price, from the NAIC (2019), the average price of an HO-3 policy in Washington in 2017 was US\$854. Similar data are not collected in Canada due to anti-trust legislation. However, a review of publicly available information places the cost of homeowners insurance in Canada between CA\$984 and CA\$1,067 (US\$748 and US\$811).¹¹

Similarly, there is little difference in the pricing and design of earthquake insurance between Washington and British Columbia as summarized in Table 2. In both jurisdictions, earthquake insurance is not required by law or by the majority of

11. The average owner occupied property insurance premium in British Columbia in 2020 was CA\$984 (US\$748) according to <https://www.businesschief.com/leadership-and-strategy/bc-leading-province-home-insurance-premiums>. Using annual statement data, an average premium could be calculated for insurers that only write personal property insurance in British Columbia. The average premium in 2017 was CA\$1,067 (US\$811). Additionally, Statista (<https://www.statista.com/statistics/580597/owned-home-insurance-cost-bc-by-home-value/>) provides some statistics based on home value. The average monthly premium for a home worth less than CA\$100,000 (US\$76,000) is CA\$43 (US\$33) in 2016. From the NAIC (2019), the monthly premium for a home worth less than US\$100,000 US\$37. For homes between CA\$100,000 and CA\$300,000 (US\$76,000 to US\$228,000), the average monthly premium was CA\$51 (US\$39) in Canada and for homes between US\$100,000 and US\$300,000, the average monthly premium was US\$58 in the U.S.

mortgage lenders. As such, consumers have the choice whether or not to purchase the coverage. One of the most popular arguments contends that the cost and design of earthquake insurance are the biggest barriers to a household’s decision to purchase earthquake insurance. (See, for example, Kunreuther, Pauly and McMorrow, 2013; Gilbert, 2016; and NAIC, 2020.) In short, the price is too high, the deductible is too large, and the likelihood of such an event is too small, making the coverage unattractive to households.

**Table 2:
Summary of Earthquake Insurance Coverage in Washington and British Columbia**

	Washington State	British Columbia
“Typical deductible” as percentage of insured value	10% - 15%	12.5%
Fixed dollar deductible available	Yes	Yes
Average cost for wood frame home	US\$1 to US\$3 per US\$1,000 coverage	CA\$0.6 to CA\$1.9 per CA\$1,000 coverage (US\$0.79 to US\$2.5 per US\$1,000 coverage)
Average cost for brick home	US\$3 to US\$15 per US\$1,000 coverage	CA\$1 to CA\$20 per CA\$1,000 coverage (US\$1.31 to US\$26.31 per US\$1,000 coverage)
Standard EQ coverages	<ul style="list-style-type: none"> Repairs to home and personal property Cost to remove debris Extra living expenses 	<ul style="list-style-type: none"> Loss or damage to property Cost to remove debris Additional living expenses
Standard EQ exclusions	<ul style="list-style-type: none"> Other perils Typically excludes landslides, mudslides, tidal waves and tsunamis 	<ul style="list-style-type: none"> Other perils Excludes landslides, snow slides, tsunamis and tidal waves
Fire following with standard homeowners insurance	Yes	Yes
Required by law and/or mortgage lenders	No	Not usually

In Washington, residential earthquake policies are fairly standardized, with most policies having a deductible between 10% to 15% of insured value (Kreidler, 2018), though higher risk properties may see deductibles closer to 25%. Goda et al. (2020), using data on actual insurance purchases in British Columbia, estimate the average deductible to be 12.5% of insured value.

The impact of the deductible is substantial. Kreidler (2018) notes that the average insured value of a home in King County, WA, was almost US\$700,000, which would imply that homeowners would be responsible for the first US\$70,000

to US\$105,000 of losses with an assumption of a 10% to 15% deductible. Higher risk properties may be responsible for US\$175,000 if the deductible reaches 25%. The median price of a home in the Lower Mainland is more than CA\$700,000 (US\$532,000), and as such, a 12.5% deductible translates into homeowners paying at least CA\$87,500 (US\$66,500) before insurance would apply.

Insurers in both countries do offer earthquake coverage with fixed-dollar deductibles, which would presumably be more attractive to policyholders. However, given the price of the high-percentage deductibles, we assume that the policies would be unaffordable in high-risk areas.

With respect to premiums, in Washington, the Insurance Information Institute (III) (2020a) states that premiums for the Pacific Northwest range from US\$1 to US\$3 per US\$1,000 coverage for a wood framed home, and from US\$3 to US\$15 per US\$1,000 coverage for a brick home.

While concise summary of pricing for residential earthquake insurance coverage in the Lower Mainland does not exist due to antitrust legislation, available information does suggest a pricing regime that is marginally cheaper than that in western Washington. Industry professionals confirmed that premiums in British Columbia range from CA\$0.6 to CA\$1.9 per CA\$1,000 coverage (US\$0.79 to US\$2.5 per US\$1,000 coverage) for a wood framed home and from CA\$1 to CA\$20 per CA\$1,000 coverage (US\$1.31 to US\$26.31 per US\$1,000 coverage) for a brick home. According to British Columbia insurance brokerage Square One Insurance (www.squareoninsurance.com), a home with a total of CA\$585,000 (US\$444,600) in coverage (including the home itself, contents and additional living expenses), would face an annual premium from CA\$225 to CA\$515 (US\$171 to US\$391.4), depending on home type and location relative to the risk. Within much of the Lower Mainland, this level of coverage is likely to be insufficient. For properties within Vancouver, online insurers are quoting premiums of CA\$550 (US\$418) and higher for coverage with a 10% deductible.¹²

And finally, another potential drawback for insurance buyers in both Washington and British Columbia surrounds what is and is not covered in a standard earthquake policy. A standard policy will cover direct shake damage to property and the costs associated with home repair, debris removal and additional living expenses during the repair process. However, a bigger risk in Washington and British Columbia involves landslides, mudslides and rock falls, and damage arising from these perils is not covered by a standard earthquake policy. The topography of these regions and general location of many properties make the plausibility of such damage higher than other regions that may not have such noted elevation gradients. Finally, in both jurisdictions, standard homeowner policies will cover losses from fire following a tremor, and if the fire makes the home unlivable, additional living expenses will also be covered.

12. Industry professionals could not explain the difference in pricing. Two possible explanations are that there may be differences in the cost of reinsurance between the two jurisdictions or because of the greater take-up rates in all of British Columbia, Canadian insurers can offer lower premiums because of their ability to successfully spread risk.

In conclusion, the design of earthquake coverage is the same in both Washington and British Columbia, and although earthquake insurance is somewhat less expensive in British Columbia, the difference, in our opinion, is not significant enough to account for the startling difference in insurance take-up rates.

Household Demographics

Although many researchers have conjectured that older and more educated individuals would purchase insurance, the empirical evidence is inconclusive. Palm and Hodgson (1992) and Palm (1995) found that household demographics were not significant factors in the decision to purchase earthquake insurance in California, but Mumo and Watt (2017) found that age and education were positively correlated with an increase in the amount of insurance purchased after the Christchurch earthquakes in New Zealand. In Canada, Goda et al. (2020) found little difference in median age between Quebec and British Columbia residents despite the significant difference in take-up rates for earthquake insurance between the two provinces.

With respect to other catastrophic losses, Atreya et al. (2015) found that age was positively correlated to the decision to purchase flood insurance, and Zahran et al. (2009) and Atreya et al. (2015) found that education was significantly and positively related to the demand for flood insurance in Florida and Georgia, respectively. In contrast, Kousky et al. (2018) found a negative relationship between education levels and the dollar amount of flood insurance purchased, but education did not affect the number of policies in force (presumably due to FEMA requirements).

We examine whether there are significant differences between household demographics in western Washington and the Lower Mainland. It should be noted that because of jurisdictional differences, collecting identical demographic and socioeconomic data between western Washington and the Lower Mainland is difficult. Furthermore, in Canada, these data are aggregated for the economic region Lower Mainland, but in the U.S., data are available at only the county and state level and some data are difficult to aggregate across counties to create a point estimate for the larger western Washington region. Canadian data were collected from the 2016 Census, and U.S. data were obtained from the Office of Financial Management (OFM) for Washington.

We provide these statistics in Table 3. We also provide data on King County (Seattle) separate from the aggregated region of western Washington, as King County comprises roughly 40% of the western Washington population. We did not separate out the Vancouver census metropolitan area (CMA) from the larger Lower Mainland because by population, the Vancouver CMA is 87% of the Lower Mainland population.

Residents in the Lower Mainland were marginally older and had marginally less education than those in western Washington, and residents in King County, WA, were considerably more educated than the other regions. Based on demographic factors, there is little difference in median ages, but if education were

positively related to earthquake purchases, King County should have the highest take-up rates.¹³ Therefore, we conclude that it is not demographic differences in households that is driving the difference in take-up rates between Canada and the U.S.

Table 3:
Demographic Variables Western Washington Versus Lower Mainland¹⁴

	King County, WA	Western WA ¹⁵	Lower Mainland, British Columbia ¹⁶
Population estimate (date of collection)	2,252,782 (2019)	5,960,610 (2019)	2,832,000 (2016)
Median age (date of collection)	39 (2019)	38.3 (2019)	41 (2016)
High school graduate or higher, % of persons over 25 (date of collection)	94.7% (2014–2018)	92.36% (2014–2018)	91.39% (2016)
Bachelor's degree or higher, % of persons over 25 years (date of collection)	51.4% (2014–2018)	37.65% (2014–2018)	35.27% (2016)

Household Income Constraints and Wealth

Whether or not insurance is too expensive is a direct function of household income and wealth at risk. Although Schanz (2018) views affordability of insurance as a greater issue in frontier and emerging economies, the high cost of earthquake coverage relative to household income may be a key reason why individuals forego the purchase of earthquake insurance.

The results in the literature are inconclusive. With respect to earthquake coverage specifically, Goda et al. (2020), in their examination of earthquake take-up rates in British Columbia versus Quebec, did not find any differences in median

13. In a country-specific comparison, take-up rates for earthquake insurance in King County exceed that of the rest of western Washington.

14. Because census data are presented as point estimates, a statistical analysis of the difference between the jurisdictions is not possible.

15. We define western Washington to be the 18 counties west of the Cascadia mountain range: Clallam, Clark, Cowlitz, Grays Harbor, Island, Jefferson, King, Kitsap, Lewis, Mason, Pacific, Pierce, San Juan, Skagit, Snohomish, Thurston, Wahkiakum and Whatcom. Due to data limitations, our calculation of median values for western Washington is the weighted average of the median values of each of the 18 counties.

16. The Lower Mainland includes the census divisions of Squamish-Lilloet, Sunshine Coast, Fraser Valley and Greater Vancouver. There are two census metropolitan areas within the Lower Mainland, Vancouver and Abbotsford-Mission.

income levels by forward sortation area (FSA).¹⁷ As such, they argued that, at least in Canada, income levels were not a determining factor in the decision to purchase earthquake insurance. Similarly, in California, Palm and Hodgson (1992) found that neither income nor equity in the home affected the decision to purchase earthquake insurance. However more recently, Athavale and Avila (2011) found a positive relationship between the income and the demand for insurance, but they commented that the relationship is relatively inelastic. Lin (2019) found that for California, a 20% increase in median income results in a 12.6% increase in take-up of earthquake insurance.

With respect to other forms of disaster coverage, Browne and Hoyt (2000), Kriesel and Landry (2004), Kousky (2017), and others find that the purchase of flood insurance is positively correlated to income levels, whereas Lo (2013) found no relation between income and the decision to purchase flood insurance, and Grace et al. (2004) found conflicting results between income and the decision to purchase flood insurance.

It has been conjectured that those with more wealth at risk are more likely to purchase insurance. Kreidler (2018) notes that homes with earthquake coverage are 65% more expensive than the average home. However, Lin (2019) did not find any relationship between appreciation or depreciation in house prices and earthquake insurance demand.

Using the same data sources (and the same caveats) as in Table 3, Table 4 provides data on household income and property values.

Ignoring currency differences, incomes in western Washington (King County) are 10.7% (23.9%) greater than the median household income in the Lower Mainland.¹⁸ However, housing values in the Lower Mainland are 133.1% (47.0%) greater than those in western Washington (King County). Households in the Lower Mainland have greater property value at risk and less income to recover after a catastrophic loss. Thus, this could be one reason why, despite the higher cost, households in the Lower Mainland purchase more earthquake insurance.

Household Risk Perception

Risk perception is the subjective judgement that people make about the characteristics and severity of a risk. Many researchers note that for many lines of business, insureds may be informed about their potential probability and severity of loss, but this is not likely to be true for low-frequency, high-severity events.¹⁹ When these insureds underestimate the likelihood and severity of a loss, insurance appears

17. Forward sortation area (FSA) is the first three characters of the Canadian postal code and is a common way to designate geographical regions in Canada. Depending on how broadly the Lower Mainland is defined, the Lower Mainland encompasses roughly 80 to 100 FSAs.

18. Recall from footnote 9, the purchasing power parity was very close to the exchange rate, and as such, \$1 in each country buys the equivalent amount.

19. We direct the interested reader to Robinson and Wouter Botzen (2019), who provide a systematic review of 80 studies of insurance demand for low-probability, high-severity events.

“too expensive,” and as such, the rational agent would forego the purchase of insurance. In a survey of California residents, Palm and Hodgson (1992) found that perceived risk was the primary factor associated with the purchase of earthquake insurance. Bastami, Mahdavi and Zarei (2012) noted similar results in a survey of Tehrani households.

Table 4:
Socioeconomic Data Western Washington Versus Lower Mainland

	King County, WA	Western Washington ²⁰	Lower Mainland, British Columbia ²¹
Population Estimate (date)	2,252,782 (2019)	5,960,610 (2019)	2,832,000 (2016)
Median Household Income	USD\$89,418 (2014–2018)	US\$79,904 (2014–2018)	CA\$72,196 (US\$55,416) (2015)
Housing Units	970,301 (2019)	2,506,999 (2019)	1,185,037 (2016)
Owner Occupied Rate	57.1% (2014–2018)	62.3% (2014–2018)	53.3% (2017)
Median Value Owner Occupied Unit	US\$493,500 (2014–2018)	US\$311,700 (2014–2018)	CA\$726,655 (US\$552,258) (2017)

Several elements affect one’s risk perception. The elements that we focus on are the nearness of recent catastrophic events, the community’s general awareness of risk, and messaging of insurers, government and media as to the importance of the protecting against potential earthquake losses.

Previous Catastrophic Events

Many authors have shown that risk perception is affected by recent similar catastrophic events, also known as recency bias (Kunreuther et al 1978; Browne and Hoyt, 2000; Zahran et al., 2009; and Kousky, 2017; among others). These authors find that the purchase of insurance coverage for catastrophic events increases after households observe a similar catastrophe. Specifically, with reference to earthquake, Lin (2019), using California data from 2003 to 2013, found that earthquake insurance take-up was immediately increased after a moderate earthquake, but the effect was short-lived (less than one year). Additionally, Lin found that if individuals experienced at least three light tremors within the last two years, there was a slight take-up in insurance. However four light shakings within three years did not affect the number that purchased earthquake insurance. Sun and Xue (2020),

20. Due to data limitations, our calculation of median values for western Washington is the weighted average of the median values of each of the 18 counties

21. Due to data limitations, the owner-occupied rate and median value of owner-occupied rate are only for two CMAs within the Lower Mainland, Vancouver and Abbotsford-Mission. These two locations account for 93% of private dwellings in the Lower Mainland.

in a survey of Jiaodong Peninsula in China, found that respondents who had experienced mild earthquakes believed a future event was more likely, but this did not affect their belief of perceived consequences nor preparedness for future earthquakes.

A significant difference between earthquake risk and other natural disasters, such as flooding, is the frequency of earthquake risk. Both Washington and British Columbia are subject to numerous earthquakes, but most are undetectable to humans. Of those that are felt by households, most cause no damage. According to the U.S. Geological Survey (USGS), the median number of tremors of M2 or greater annually in Washington is 190. The situation is similar in Canada: Southwestern British Columbia experiences more than 400 earthquakes a year, most of them being insignificant (Natural Resources Canada, 2011).

With respect to more significant earthquakes, the last noteworthy earthquake to hit Washington was the Nisqually earthquake on Feb. 28, 2001. This M6.8 earthquake injured 400 people, caused one death and, at the time, resulted in roughly US\$300 million in insured payouts. Total economic damage was estimated at US\$2 billion. This event produced only minor damage in Canada, and there was no injury or loss of life. The city of Vancouver (2001) noted that while there was little damage, “the most significant affect [sic] of the earthquake was the psychological impact that this event had on the citizens of Vancouver. [...] An intensive series of media briefings immediately following the earthquake, coupled with follow up interviews, were conducted to restore public confidence in Vancouver’s level of preparedness.”

The last temblor that caused significant damage in western Canada was an M8.1 earthquake in the Queen Charlotte Islands (now Haida Gwaii) in August 1949.²² Because this area was largely unpopulated, there were no fatalities or injuries, just property damage. Although we could find no dollar estimate of the property damage, Natural Resources Canada (2018) reported, “The shaking was so severe on the Haida Gwaii that cows were knocked off their feet, and a geologist with the Geological Survey of Canada working on the north end of Graham Island could not stand up. Chimneys toppled, and an oil tank at Cumsheewa Inlet collapsed. In Terrace, on the adjacent mainland, cars were bounced around, and standing on the street was described as ‘like being on the heaving deck of a ship at sea.’ In Prince Rupert, windows were shattered and buildings swayed.”

Given that western Washington has had more recent experience with a significant earthquake, one would expect that insurance penetration rates would be higher in western Washington, not the Lower Mainland.

Community Awareness and Relative Perception of Earthquake Risk

If communities do not have a general awareness of risk, then it seems unlikely that individual households will believe they are in danger. Therefore, we examine whether there is greater risk awareness on a societal level in British Columbia compared to Washington. Unfortunately, to the best of our knowledge, there has

22. There was an M7.8 earthquake near Haida Gwaii in October 2012, which produced minor damage only.

been no formal survey of awareness and understanding on earthquake risk in the Pacific Northwest. A survey of the literature reveals studies on earthquake risk perception in different countries, including China, Indonesia, Japan, Lebanon, New Zealand, Romania and Switzerland. Palm (1995) examined earthquake risk perception and insurance in California following the 1994 Northridge earthquake. Le Pan, in detailing the lack of a formal earthquake insurance backstop arrangement in Canada, also noted that there is no “regular survey data on consumer behavior and attitudes towards risk” (2016, p. 7). Thus, our discussion below relies completely on anecdotal evidence.

Our primary piece of anecdotal evidence is participation rates in the ShakeOut. The ShakeOut is an annual global event promoting earthquake awareness and preparedness.²³ If indeed public awareness was higher in British Columbia than Washington, one might expect higher participation in ShakeOut-related activities in British Columbia. In 2019, more than 1 million British Columbians, about 20% of the population, participated in the event. In the same year, roughly 1.3 million people, or 17% of the state population, participated in Washington. This suggests that there is no significant difference in awareness in the two jurisdictions.

Participation in the California ShakeOut dwarfs the numbers in both Washington and British Columbia on both total number of participants and percentage of population basis. The first ShakeOut event in 2008 generated 5.3 million participants, but that rose to 10.7 million (or 27% of the California population) in 2019.

This leads us to our discussion on relative risk perception. We conjecture that earthquake insurance take-up rates might be lower in Washington because, compared to California, residents in Washington feel safer. Although earthquake risk in Washington is as high as California, six of the 10 costliest earthquakes for insurers in the U.S. have occurred in California, and only the 2001 Nisqually earthquake in Washington made the top 10 list of the costliest earthquakes in the U.S. (III, 2020a). Given most media focus for the earthquake peril in the U.S. is often in California—notably the San Andreas Fault—it may be anecdotally assumed that seismic risk is lower near the Cascadia subduction zone.²⁴

The role of relative risk perception on the decision to purchase earthquake insurance has led to low earthquake insurance penetration in eastern Canada: It is well recognized in Canada that parts of British Columbia—specifically Vancouver Island and the Lower Mainland—are the most active seismic regions in Canada, but there are locations in Quebec that also have significant seismic risk on par with the Lower Mainland. However, most residents in Quebec are unaware of this risk. Surveys conducted by the IBC have found low levels of risk perception in Quebec

23. The ShakeOut is a “drop, cover and hold on” global earthquake preparedness drill held annually at 10:15 a.m. (local time) on the third Thursday in October. Resources are provided for home, workplaces, government agencies, organizations and schools to educate and prepare for an earthquake. We direct the interested reader to <https://www.shakeout.org> for more information.

24. Similar risk attributions are often noted for the wildfire peril in California, despite several major wildfires leading to hundreds of millions U.S. dollars or greater in damage in the past decade in the states of Colorado, Tennessee and Texas.

(Goda et al., 2020). As a result, take-up rates for earthquake insurance in Quebec are less than 5%, and less than 8,000 individuals out of a population greater than 8.5 million participated in the ShakeOut (or La Grande Secousse as it is known locally) in 2019.

This leads us to conjecture that although risk awareness is important, relative risk perception may also play a significant role in the decision to buy insurance.

Messaging of Insurers, Governments and Media

The decision to purchase (or not purchase) earthquake insurance is influenced by the messaging of insurers, governments and the media. For example, the OECD (2018, p. 19) observes that “governments can help address some of the challenges to the insurability of earthquake risk by investing in measures to improve risk awareness.” Because homeowners exhibit systematic biases in judging low-probability events, Kousky and Kunreither (2018) called upon the public and private sectors to promote risk understanding. Of particular importance is how the risk is framed so that there is a greater incentive to purchase insurance for catastrophic losses (Kunreuther, Meyer and Michel-Kerjan, 2014).

Thus, we explore the relationship between messaging of the insurance industry, governments and the media as to the importance and necessity of earthquake insurance and subsequent take-up rates. As noted above, no primary survey on risk perception has been undertaken in the Pacific Northwest, and as such our discussion here is also anecdotal in nature.

The actions of governments could potentially decrease an individual’s perception of risk. Browne and Hoyt (2000), in a study of flood risk, noted that government expenditure in flood loss mitigation creates a false sense of security, reducing the perceived value of insurance. Whether this holds true in earthquake insurance is unclear since, unlike flood mitigation efforts, investments to improve infrastructure from earthquake damage would not necessarily decrease risks to individual households. In fact, it is entirely plausible that the opposite effect might hold, and government investment in infrastructure might increase awareness of the need for proactive behavior (including expenditures in mitigation and the purchase of insurance).

As noted previously, in neither jurisdiction is earthquake insurance mandated by governments (or mortgage providers), and as such, insureds must be convinced that such a purchase is valuable. Kunreuther (1984) observed that the take-up rate depends on how insurance companies market voluntary disaster insurance and the extent to which governments provide information regarding the hazard itself and available protection.

The Washington State Office of the Insurance Commissioner (OIC) (n.d.) provides information on what earthquake insurance is, and what it does and does not cover. It does not provide a recommendation as to whether earthquake insurance should be purchased. Similarly, the U.S. Geological Survey (USGS) (n.d.) lists 15 factors that should be considered in making the purchasing decision, including proximity to active faults, design and construction of house, local soil and slope conditions, value of the house, and design and price of earthquake insurance

policies, but the USGS does not make any statement as to whether an individual should purchase insurance.

Where a statement is made, messaging in the U.S. seems to focus more on the individual choice to purchase. For example, the PNSN (n.d.), in the Frequently Asked Questions (FAQ) page of its website, responds to the question about purchasing earthquake insurance as follows: “That is an individual decision, which depends on the risk that homeowners are financially willing to take. It also depends on their confidence in the quality of their homes, since there is quite a large deductible on most policies. Commonly the policies only pay for damage exceeding 5 to 10% of the value of a house. Some seismologists do have earthquake insurance.”

This message was echoed by the Washington state OIC. After an earthquake in 2019 in Snohomish County, a spokesperson for the office, when asked if earthquake insurance should be purchased, was quoted as follows: “A lot of it depends on how much equity you have in your home — if you own your home outright, it’s probably a good idea, the location of your home, the foundation and how it’s structured right now, and what kind of contents and other things you have on your property.” (Bowman, 2019). Further details in the report listed the unattractiveness of the design of the earthquake policy.

The unattractiveness of earthquake insurance has been repeated in the popular press in western Washington: The price is too high, the deductible is too large, and the likelihood of such an event is too small, making the coverage unattractive to households.²⁵ We did not find a similar message in popular press in British Columbia.

The British Columbia Financial Services Authority does not provide earthquake insurance information to consumers. The IBC (n.d.) provides a brief overview of the coverage and states, “Earthquake coverage is especially worth considering if you live in an earthquake-prone region.” After an M4.6 earthquake in 2018, a broker, when asked about earthquake insurance, replied, “Earthquakes, particularly those large enough to cause massive damage, are practically impossible to predict. Can homeowners afford not to insure the risk?” (Moorcraft, 2018).

In British Columbia, some insurance companies and brokers provide information on earthquake insurance on their web pages, with some, but not all, recommending that earthquake coverage be purchased. However, the messaging that earthquake insurance is essential is not universal. Additionally, earthquake insurance is not mentioned on the ShakeOut website for either Washington or British Columbia., but the IBC is a sponsor of the British Columbia ShakeOut.

25. See, for example, articles published by *The Seattle Times* (<https://www.seattletimes.com/seattle-news/earthquake-insurance-prices-soar-in-washington-companies-hold-all-power/>), MyNorthwest (<https://mynorthwest.com/1448889/earthquake-insurance-washington-state/>) and NPR (<https://www.npr.org/2019/07/09/739999709/why-only-13-of-california-homeowners-have-earthquake-insurance>), and online websites such as Policygenius (<https://www.policygenius.com/homeowners-insurance/is-earthquake-insurance-worth-it/>).

Anecdotally, although there is slight difference in messaging between the U.S. and Canada (“it is an individual choice” versus “you might want to consider”), it seems unlikely that this difference could lead to vast differences in the take-up rates of earthquake insurance.

Expectation of Post-Disaster Relief

Moral hazard is created if those affected by natural disasters anticipate that they will be bailed out by ex post government support. When individuals expect to be eligible for other forms of disaster assistance, demand for insurance naturally falls, and there is less of an incentive to purchase insurance. Browne and Hoyt (2000) refer to this phenomenon as “charity hazard.” Kelly and Kleffner (2003) show that the expectation of government assistance also affects the amount spent on mitigation. As the amount of anticipated government aid increases, rational individuals purchase less insurance and spend less on mitigation. This increases the protection gap, as the overall severity of losses will be greater (assuming that mitigation reduces severity), and there will be less insurance coverage.

There is evidence that the presence of readily available disaster assistance crowds out insurance spending. FEMA’s Public Assistance (PA) grants assist municipalities with debris removal and infrastructure repair with no requirement that households within the affected locale purchase flood policies. Davlasheridze and Miao (2019) found that for every 10% increase in flooding-related PA grants received by a county, flood insurance take-up rates decreased by 1.5% in the following year.

Kousky et al. (2018) examined the impact of future flood insurance purchases after a ZIP code receives Individual Assistance (IA) grant payments from FEMA. They found that the average amount of insurance purchased decreased by \$US4,000 to \$US5,000, which was larger than the average size of flood-related grants. The number of flood policies purchased after receiving aid did not fall presumably because a requirement of receiving FEMA assistance is that future FEMA aid will not be available if the property owner is uninsured. Both Kousky (2017) and Davlasheridze and Miao (2019) found that this requirement is what drove take-up rates for insurance after major hurricanes. While this requirement may ensure that individuals insure for more “common” disasters such as flood and windstorm, such a requirement, in our opinion, is unlikely to increase the take-up rates for earthquake insurance due to the extreme rarity of a significant event.

Raschky et al. (2013) examined the crowding out effect of government relief in Austria and Germany for private flood insurance. In both countries, the presence of government relief programs reduced the demand for flood insurance. The impact was stronger in Austria, which had guaranteed but partial relief, than in Germany, which had complete but uncertain funding.

In Canada, disaster assistance for uninsurable losses is provided to property owners at the provincial and territorial level through provincial Disaster Financial Assistance (DFA) programs. Provincial and territorial governments are responsible for the design, development and delivery of disaster financial assistance, and the

federal government provides funds to provincial governments when “eligible expenditures exceed and established initial threshold (based on provincial or territorial population)” (Public Safety Canada, 2020). Unlike the U.S., the Canadian federal government does not provide aid directly to affected individuals but only to provincial and territorial governments.

Provincial and territorial emergency management agencies that handle these funds are clear that financial assistance will not be forthcoming if private insurance for a particular peril is available, but the property owner opted not to purchase it. The province of British Columbia (2016) states, “Earthquake damage is insurable and, therefore, not eligible for DFA. Home and business owners should check with their insurance agent to make sure they have appropriate earthquake coverage.” The province also states, “Earthquake insurance is reasonably and readily available for single family residential homes across all of BC. The phrase ‘readily available’ means that a person could obtain this insurance from a local agent or broker. ‘Reasonably available’ should not be confused with affordable. What a person can afford is subjective and specific to that person. What is important is that the price of the insurance was reasonable considering the risk.”

Since there has not been a major earthquake, we cannot say with certainty that the provincial government of British Columbia would not provide disaster relief. To date, however, the government has not provided funding for losses that are ultimately insurable.

Disaster assistance in the U.S. is considerably different from that in Canada. FEMA provides grants and other assistance such as free emergency housing and low interest loans to homeowners who need financial support following a disaster. Michel-Kerjan, Lemoyne de Forges and Kunreuther (2012) and Kousky et al. (2018) comment that federal aid is now routinely offered after most disasters. And, on top of federal aid, individual states may also offer disaster assistance programs.

FEMA’s IA program administers seven programs to aid communities after the president has declared an emergency or major disaster. Its Individuals and Households Programs (IHP) provides funds for eligible households that are uninsured or underinsured; any eligible insurance policies must be the payer of first resort. The maximum grant available is US\$34,000. As seen in Table 5, however, for catastrophes in which insurance is easily available, only a small fraction of applicants receives the maximum amount. Walls and Hernandez Cortes (2018) noted that most homeowners receiving disaster aid did not have flood insurance. With respect to earthquake funding, FEMA approved more than US\$13 million in disaster rental assistance and repair grants after the Nisqually earthquake in 2001.

Michel-Kerjan, Lemoyne de Forges and Kunreuther (2012), in a graph of the number of U.S. presidential disaster declarations from 1958 to 2010, displayed the steady increase in disaster assistance in the U.S. Furthermore, payments have grown from US\$182 million in 1992 to US\$12.6 billion in 2019, based on the funds available via congressional appropriations in the Disaster Relief Fund (DRF). This does not account for additional supplemental costs added on top of the budgeted appropriations (U.S. Congressional Research Service, 2020). While these funds have not come close to fully accounting for overall uninsured disaster losses in the

most high-loss years (such as 2005, 2012, 2017 or 2018), they have provided significant relief to state and local communities during the recovery and subsequent rebuilding.

**Table 5:
FEMA Average Payout and Estimates of Property Damage**

Hurricane	IHP Average Payout (US\$)	FEMA Estimate of Property Damage (US\$)
Harvey	8,918	13,100
Irma	2,097	4,454
Maria	3,377	7,628

It is difficult to measure the impact of role charity risk plays on the take-up of earthquake insurance in Washington. However, according to an OECD survey of 31 countries (2018), the U.S., but not Canada, noted that a high level of underinsurance existed because of the expectation of government aid following an earthquake. Thus, we contend that the expected availability of disaster assistance affects the take-up rates of earthquake insurance in the U.S.

National Culture

We also believe the willingness to purchase optional earthquake insurance is influenced by national culture. Whereas Canada is known for “peace, order and good government,” the U.S. motto is one of “life, liberty and the pursuit of happiness.”²⁶

Hofstede (1980; 1985; 2001), in his foundational work, defined four (and later expanded to six) dimensions of national culture. Although similar across many dimensions, the American culture rates higher on the traits of individualism and masculinity, whereas the Canadian culture ranks higher on long-term orientation. These traits imply that the U.S. culture is more individually focused and competitive, whereas in Canada, there is more of a preference for cooperation.

Other researchers have also noted key cultural differences between the two nations. Adams (2014, p. 58), summarizing a survey of Canadian and American attitudes, noted that in the U.S., there is “a deeper emphasis on individualism, [and] a renewed suspicion of government.”²⁷ Kerans (2014) suggested that this is because the U.S. was created by revolution with Great Britain, whereas Canada was created

26. When we reference Canadian culture, we are focusing on English-speaking Canada. Quebec is a francophone province, and Quebec culture aligns more with western European countries than with English-speaking Canada.

27. This survey was undertaken when the U.S. had a Democratic president and Canada had a Conservative prime minister. We conjecture that this observation is even more valid in 2020.

by agreement with Great Britain. Regardless as to the underlying reason for this divergence, this led Thomas and Biette (2014, p. 412) to conclude that for Americans, “There is a fundamental lack of trust in all elected officials—even at the municipal level—such that local residents are spoiling for a fight on nearly any issue.”

This fundamental difference in culture may affect the willingness to purchase insurance for low severity events. Ridolfi et al. (2020), in a theoretical study of flood losses, argued that the world and societal views influence risk perception, risk judgement and preferences for risk management strategies, which include neglecting and downplaying the risk and its impact. In particular, societies that are more individualistic are most likely to downplay and underestimate the level of risk.

However, fundamentally, we believe that British Columbians buy earthquake insurance because they are told they should. Canadians are essentially “rule followers.”²⁸ The same is not true for Americans. Their strong sense of liberty and individualism, along with a distrust of government, makes it difficult for governments to encourage households to purchase insurance against earthquakes or other natural disasters.

Because Americans are very individualistic, they are more likely, as noted earlier, to underestimate the potential risk. This has resulted not only in low take-up rates for earthquake insurance in western Washington, but also in California, where roughly 10% of households have earthquake insurance. A similar result holds for subsidized flood insurance; the highest take-up rates in the hurricane -affected states is only 23.9% in Louisiana, whereas Mississippi and Alabama have take-up rates less than 5%.²⁹ While it is true that the highest flood-risk areas often result in the highest premium costs for flood insurance, the same is not true for other communities. And there have been enough flash flood or riverine flood events in non-coastal areas that should serve as enough reminder for residents to purchase flood insurance.

Investments in Mitigation

Homeowners may decide to invest in mitigation instead of purchasing optional insurance. Grace and Klein (2002), in a study of realtors, found that many homeowners preferred mitigation as an alternative to insurance. Kunreuther and Pauly (2006, p. 107), in stating that “insurance appears to be treated by many individuals as an investment rather than a protective measure,” noted the tendency of homeowners to lapse on coverage if they do not face losses in subsequent years.

28. Dr. David Fisman, an epidemiologist at the University of Toronto in a tweet on July 11, 2020, noted, “Unscientific and non-data-based observation: It is effing bonkers to see how widespread masking (indoor and out) has become in East York since indoor masking was mandated in City of Toronto. We are a country of rule-followers.” See also McManus (2020), who writes, “It’s hard to avoid giving some credit to the elusive notion of national character: Canadians—unlike Americans—pride themselves on being a nation that generally follows the rules.”

29. Author calculations using data from U.S. Census Bureau (2019) and FEMA (2020).

However, investments in mitigation can be recouped when a house is sold (Gatzlaff, McCullough, Medders and Nyce, 2018). Mitigation is even more attractive if a jurisdiction offered a rebate or subsidy for activities undertaken.

There is no subsidy or rebate available to homeowners in British Columbia for retrofitting private homes to mitigate against earthquake damage. FEMA, through the Building Resilient Infrastructure and Communities (BRIC) grant, provides states, tribes and local communities (but not households) funds to undertake pre-disaster hazard mitigation. There may be a small number of informal grants available to a small number of homeowners for small expenditures,³⁰ but, unlike California with its Earthquake Brace + Bolt (EBB) program (<https://www.earthquakebracebolt.com/>), there is no widespread funding for retrofitting private homes in Washington.

On paper, this may seem like a reasonable trade-off, but the larger question remains how many residents in high-risk areas such as British Columbia or Washington undertake mitigation. We conjecture not many. Kunreuther and Michel-Kerjan (2009) reported that 5% to 9% of Californians in earthquake-prone areas undertook mitigation. After the hurricane seasons of 2004 and 2005, a survey of homeowners along the Atlantic and Gulf coasts revealed that 83% of homeowners had not invested in low-cost mitigation measures to reduce losses, and 68% had not undertaken any emergency preparedness measures.

Additionally, other research suggests that insurance and expenditures may be complements, and not substitutes. In a survey of homeowners affected by Hurricane Sandy, Wouter Botzen, Kunreuther and Michel-Kerjan (2019) found that respondents who purchased flood insurance voluntarily or mandatorily undertook more risk-reduction activities (such as using water-resistant materials and elevating electrical installations) than respondents without flood insurance. However, those who were required to purchase insurance were less likely to invest in flood shields and sandbags than those who did not have flood insurance.

Data are not available as to the number of households in western Washington or the Lower Mainland that have spent money on risk-reduction activities. But, given the conflicting evidence as to whether insurance and mitigation expenditures are complements or substitutes, as well as the low investment in risk-reduction activities in other natural disaster-prone locations in the U.S., we do not believe that differences in take-up rates are related to investments in mitigation.

Our brief, and admittedly somewhat anecdotal, comparison on western Washington and Lower Mainland British Columbia suggests that differences in take-up rates of earthquake insurance are not driven by product design or pricing or household demographics or other socioeconomic factors. Anecdotally, the general awareness of earthquake risk appears to be the same between both regions, although because of a comparison to California earthquake risk, perhaps those in western Washington believe they are relatively safer. However, we also note that take-up rates for earthquake insurance in California are roughly the same as western

³⁰ For example, the Phinney Neighborhood Association in Seattle has a tool-lending library, special retrofit loan products, and grants for low- to moderate-income homeowners.

Washington. We believe the two key factors driving the difference in take-up rates are national culture and the expectation of post-disaster financial assistance.

Policy Options

Our policy options listed here are based on our brief case study above. Thus, our first policy option would entail a more rigorous study of risk perception, awareness and impediments in purchasing earthquake insurance. Our recommendations below arise from our belief that the key factors influencing the low take-up rates in western Washington are national culture and the expectation of post-disaster financial assistance. As such, we expect that solutions to increase the purchase of voluntary insurance for catastrophes that have worked in other countries will not necessarily work in the U.S. With this caveat, we summarize potential policy options below.

Improve Affordability

Much work has been done in the U.S. to improve the affordability of flood insurance, but the same cannot be said about earthquake insurance. If indeed household wealth was a barrier to the take-up of earthquake insurance, governments could provide subsidies to potential insureds. Allowing insurance premiums to be tax-deductible would also reduce the cost of insurance. Community rating (offering communities the same price for earthquake insurance regardless of the underlying risk) could also be used to subsidize high-risk areas. However, Naoi et al. (2010), in a Japanese study, found that community rating significantly reduces earthquake insurance purchases in relatively lower risk areas. Therefore, they argued against any form of cross-subsidization. Kunreuther and Michel-Kerjan (2009) also stated that policies need to be risk-based and suggested that insurance stamps (similar to food stamps) could assist low-income households with the purchase of earthquake coverage.

Premiums could be lowered if tax credits or similar incentives were offered to insurers. One obvious way to reduce costs is to change how insurer surpluses are taxed. Kousky and Cooke (2012), among others, noted that premiums for catastrophe coverages could be lowered if it were easier for insurers to build surplus through “tax-deferred catastrophe reserves.”

Government partnerships could also improve affordability. The creation of Public Private Partnerships (P3), as seen in Japan or New Zealand (OECD, 2018) and suggested for earthquake coverage in Canada by Kelly, Kleffner and Kelly (2020), could incent more insurers to offer coverage in Washington. Such

mechanisms may both lower premiums and also increase the number of insurers offering residential earthquake coverage.³¹

LaTourrette, Dertouzos, Steiner and Clancy (2010) calculated the elasticity of demand for earthquake insurance in California and estimated that a 10% reduction in price would result in a 4.8% increase in the number of households that purchase earthquake insurance. Based on this and the low take-up rates for subsidized flood insurance, we contend that improving affordability is unlikely to increase earthquake insurance take-up rates to the level needed.

Product Redesign

Considerations may also be given to a fundamental makeover of the typical property insurance policy or, at the very least, to the creation of an optional product that would fold all hazards into a single cover, creating a true “all perils” or “all risks” coverage (see, for example, Kunreuther, Pauly and McMorro, 2013). There are many who advocate for a simple product with a single deductible that would include all hazards with no exclusions. This would solve informational problems in which insureds believe they are indeed covered for earthquake damage. It would also eliminate situations in which damage is simultaneously caused by both covered and excluded perils (for example, fire-following and earthquake or overland flood and windstorm).

However, this will most likely increase the cost of the policy if it is actuarially priced, and if it is a voluntary coverage, we suspect it would create even a greater protection gap if fewer households would be willing to pay the higher premium. It is possible that an “all perils” coverage could exacerbate the protection gap.

Another product redesign would be to change the duration of the policy. Kunreuther and Michel-Kerjan (2009) suggest that insurance penetration could be improved with long-term (multi-year) insurance contracts. The benefits of such contracts are twofold: Long-term policies provide homeowners stability in prices, as well as assurance that the insurance company will not cancel the policy after a severe disaster. Second, long-term policies also provide the incentives for homeowners to invest in mitigation. However, since such a product is not currently offered, we do not know its impact on take-up rates of earthquake insurance.

Compulsory Insurance/Mandatory Purchase Requirement

Washington could legally require that all property owners purchase earthquake insurance on the private market. Arguments can be made that such a requirement has numerous social benefits, including relieving taxpayers of the burden of paying into disaster assistance programs and improving community resiliency and supporting faster recovery after a catastrophic earthquake. However, given that, as

31. However, Kreidler (2018) argues that the market is fairly competitive already even though two insurers sell more than half of the residential coverages in the region.

a nation, Americans do not want to be told what to do, it may be difficult to get political traction to make insurance compulsory.

One concern is that unlike California, insurers are not required to offer earthquake insurance in Washington, and if coverage is going to be mandatory, then consumers need to be able to easily purchase earthquake coverage. One solution to increase supply would be to legislate insurers providing residential property insurance in the state to offer earthquake insurance, as is the case in California and Japan (OECD, 2018). We expect that insurers in Washington would demand an entity similar to the California Earthquake Authority (CEA) if such a law were drafted.

Another way to achieve this is to institute an earthquake insurance mandatory purchase requirement (MPR) in high-risk seismic areas, similar to how flood risk is handled in the U.S. For flood risk, the MPR requires federally backed or regulated lenders to make borrowers purchase and maintain a flood insurance policy when they provide a mortgage in a 1% annual chance flood plain. A similar requirement for earthquake coverage could be made in areas with high seismic activity. There are, however, widespread reports of flood insurance being purchased only in order to obtain a mortgage, with the policy then being allowed to lapse at renewal.³² Measures, primarily better monitoring with sanctions for noncompliance, would need to be taken to ensure that this would not occur with earthquake insurance.

However, it is likely that this would not be a politically acceptable decision. After the Northridge earthquake, attempts by Fannie Mae and Freddie Mac to institute an earthquake MPR in California were blocked by the California legislature. Current legislation states that the CEA will cease writing new earthquake insurance policies if either government association institutes an MPR as a condition of purchasing a mortgage (California Insurance Code [CIC]).

Another option, which might be politically more palatable, would be to offer earthquake coverage through a mechanism similar to a negative option upselling practice; homeowners would have automatic coverage bundled with their standard homeowners policy unless they opt out. The OECD (2018) notes that earthquake insurance penetration rates are higher in countries where such a bundling mechanism exists. Such a regime would have to be carefully conceived and managed to ensure that property owners are properly counselled and that their choice is clearly documented. Additionally, it is likely that such a mechanism would need approval from the Federal Trade Commission (FTC).

If insurers cannot be mandated to offer coverage, then the state itself through a P3 arrangement could insure earthquake losses. Models to finance compulsory

32. Beyond earthquake, the flood peril is one of the more challenging perils in the U.S. Given that a standard mortgage often lasts 30 years, basic statistics indicate that a home in that 100-year floodplain has a better than 1-in-4 chance of experiencing a flood during the life of the mortgage. Kriesel and Landry (2004) estimate that up to one-half of those are required to carry flood insurance do so. However, Rosoff and Yager (2017) show that there are just more than 6.9 million occupied housing units in the 100-year floodplain, and the III (2020b) reports 5.1 million NFIP policies in force, of which roughly 85% are for residential properties, giving an estimate of just more than 60% of households that are required to carry flood insurance actually do.

earthquake insurance with the government as the insurer exists in both Iceland and Spain. The Natural Catastrophe Insurance of Iceland (NTI) and the Consorcio de Compensación de Seguros (CCS) are government-owned companies that provide coverage for damage arising from earth movement and floods in Iceland and natural and man-made catastrophes in Spain. The CCS automatically covers losses not covered by private insurers. In both countries, insureds pay a flat rate as a percentage of property value to receive protection. Premiums are collected by private insurers and then passed on to the government insurer.

Eliminate or Modify Disaster Assistance

Reducing the availability of post-disaster financial assistance might also increase take-up rates of earthquake insurance. Similar to the Canadian approach, individual household disaster assistance could be available only for losses that are not covered by private insurance. Or disaster assistance could be available only to those who have purchased primary insurance protection but have losses exceeding what insurance will pay.

We see two key issues with this. First, it is not evident that the federal or state government would have the political appetite for such a stance, as this would affect more than just aid for earthquake coverage. Secondly, as shown by Kousky et al. (2018), even when the provision of disaster aid requires the future purchase of voluntary flood insurance, once individuals receive disaster funding, they reduce the amount of insurance purchased in the future, and the reduction in the amount of insurance purchased exceeds the disaster aid provided. Thus, the protection gap still exists.

Coverage Bundled with Property Tax

Our potential solutions above largely rely on insurance companies offering protection via (mostly) traditional mechanisms, with the purchase of protection being largely optional. In these solutions, the government may have a role in improving affordability by acting as the primary insurer, or providing a liquidity or solvency backstop to the industry.

A different solution is offered by the Property Tax Compensation Fund, which provides coverage against terrorism losses in Israel. Instead of an insurance mechanism (either voluntary or compulsory), mandatory coverage is financed through property taxes. Mandatory coverage is for direct damage to property (other than household contents), but additional insurance is optional to cover household contents. Governments can use the proceeds of the tax to create reserves to fund future earthquake reserves or purchase ILS such as catastrophe bonds to provide coverage. Although we believe this to be an elegant solution, we acknowledge again that the amount of political willpower to create such a scheme may exceed the appetite of the state government.

Concluding Remarks

Several theories exist as to why take-up of earthquake insurance in many countries—especially in earthquake-prone regions along the Pacific Ocean’s “Ring of Fire”—tends to be low given the significant risk of a temblor in a given region, with explanations that cover both the demand side and the supply side of the market. Reasons for poor levels of take-up range from the unattractiveness of the policy cost and design, household income constraints, limited overall awareness of earthquake risk, lack of understanding of insurance coverage, the expectation that the government will compensate losses (so-called charity hazard), and lack of availability of coverage (OECD, 2018; Kousky and Cooke, 2012; Kunreuther and Michel-Kerjan, 2009; among others).

Our anecdotal evidence suggests that earthquake coverage may be marginally cheaper in Canada, but the difference is fairly small. And, as such, we do not believe it plays a significant role in low take-up rates for earthquake cover in western Washington compared to the Lower Mainland. There also does not seem to be a lack of availability.

Using governmental census data, we argue that differences in take-up rates do not seem to be driven by household demographics or socioeconomic status. Indications are that general awareness of risk is also not likely a significant driver of the underinsurance issue in Washington, as awareness programs (active involvement in annual ShakeOut events) are very similar in both places.

Rather, we suspect it is a combination of the expectation of post-disaster relief funding and that Washingtonians tend not to purchase earthquake cover largely due to issues related to culture. (Simply, Americans are fundamentally different from Canadians and that the former do not relish being told what to do by authorities.) However, primary survey data on the issues—risk perception and awareness, earthquake insurance design, pricing and availability, household demographics, culture, and the role of post-disaster relief—raised in this paper should be collected and analyzed.

Because of these conjectures, we argue that improving affordability or redesigning the product will likely not significantly increase take-up rates. Although greater penetration may be achieved by making coverage compulsory, implementing mandatory purchase requirements or by making current and future disaster assistance contingent on insurance coverage, we note that penetration of flood coverage, which is subsidized and has a mandatory purchase requirement, is also woefully inadequate in the U.S.

If greater penetration of earthquake protection is indeed an important policy goal, a possible option is to bundle coverage with property taxes and have the state be the primary insurer for earthquake coverage (similar to terrorism coverage in Israel). However, we acknowledge the difficulty in setting up such a mechanism.

Our findings generalize beyond earthquake coverage and the Pacific Northwest. In particular, our findings are relevant when considering the impact of climate change. Although climate change does not have any connection to earthquake

frequency or severity, climate change will increase weather-related risks in many geographic locations in the U.S. This increased risk will require both insurers and governments to take steps to ensure that adequate protection against catastrophic losses is present. As the risk from natural perils only grows, the need to enhance awareness to reduce the protection gap and to explore nontraditional mechanisms of improving coverage will be necessary to ensure the resilience of communities affected by natural disasters.

Appendix A: Overview of Common Homeowner Policy Provisions

The Insurance Bureau of Canada (IBC) and the Insurance Services Office (ISO) in the U.S. provide model wordings for homeowners insurance policy. The policy provisions are very similar identical, and indeed in some parts, the wordings are identical. In this table below, we provide a high-level summary of the two policies. According to the NAIC (2019), the HO-3 policy is the most common policy sold in the U.S., and as such it is our basis for comparison.

	Canada (Comprehensive Policy)	U.S. (Homeowners 3 – Special Form)
Scope of Coverage	<ul style="list-style-type: none"> Dwelling and attached structures. Permanently installed outdoor equipment. Outdoor trees, shrubs, plants and lawns (up to 5% of total coverage). Additional detached structures on premise. Personal property on and temporarily away from premise. 	<ul style="list-style-type: none"> Dwelling on the "residence premises," including structures attached to the residence. Other structures on "residence premises." Outdoor trees, shrubs, plants and lawns (up to 5% of total coverage). Personal property owned or used by an "insured" while it is anywhere in the world.
Special Limits of Liability for	<ul style="list-style-type: none"> Jewelry, watches and gems. Numismatic property and stamps. Securities and money. Watercraft. 	<ul style="list-style-type: none"> Money, bank notes, bullion and gold. Securities, accounts, deeds, passports, tickets and stamps. Watercraft and trailers.
Loss of Use	<ul style="list-style-type: none"> Additional living expenses (up to 30 days). Fair rental value (up to 30 days). Prohibited access by civil authority (up to two weeks). 	<ul style="list-style-type: none"> Additional living expenses (for the shortest time required). Fair rental value (for shortest time required). Civil authority prohibits use (up to two weeks).
Loss or Damage Not Insured	<ul style="list-style-type: none"> Commercial property. Property vacant for > 30 days. Limited coverage for buildings under construction. Animals birds or fish. Motor vehicles. Aircraft. Property of tenants. 	<ul style="list-style-type: none"> Structures from which "business" is conducted. Animals birds or fish. Motor vehicles. Aircraft. Property of roomers, boarders or other tenants.
Uninsurable Perils	<ul style="list-style-type: none"> Criminal acts by policyholder. Nuclear incident or radioactive material. War, invasion or civil war. Damage caused by birds, vermin or rodents. Damage caused by rust, corrosion, rot or bacteria. Damage caused by snowslide, earthquake, tsunami, landslide or other earth movement. Damage caused by wear and tear. Flood. Water damage caused by the backing up or escape of water from a sewer, sump or septic tank or caused by ground water or rising of the water table. 	<ul style="list-style-type: none"> Theft committed by an "insured." Nuclear hazard. Intentional loss. War. Damage caused by birds, rodents or insects. Damage caused by mold, fungus or wet rot. Earth movement. Damage caused by wear and tear. Flood. Water which backs up through sewers or drains. Water below the surface of the ground.
Legal Liability	<ul style="list-style-type: none"> Claims occurred basis. Unintentional bodily injury (BI)/property damage (PD) caused arising out of actions of the policyholder anywhere in the world or ownership of covered premises. 	<ul style="list-style-type: none"> Personal liability excludes expected or intentional injury and injury arising out of a premise that is not an "insured location."

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Cummins, J. David and Richard A. Derrig, eds., 1989. *Financial Models of Insurance Solvency*, Norwell, Mass.: Kluwer Academic Publishers.

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