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## TAKE A LOAD OFF FANNIE: THE GSES AND UNINSURED EARTHQUAKE RISK

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### EXECUTIVE SUMMARY

Earthquakes are among the most devastating and economically destructive natural disasters, with the 1994 Northridge earthquake still ranking as the fifth-costliest disaster in U.S. history.<sup>1</sup> Yet unlike other common perils such as floods, fires and windstorms, the overwhelming majority of earthquake risk in the United States is completely uninsured. Even in California, the most earthquake-exposed state in the union, only about 13.3 percent of residences maintain coverage for earthquake damage, according to the most recent survey completed by the state insurance department.<sup>2</sup>

1. Nathaniel Meyersohn, "The costliest natural disasters in U.S. history," *CNN Money*, Sept. 11, 2017. <https://money.cnn.com/2017/09/11/news/costliest-natural-disasters/index.html>.

2. "Earthquake Premium and Policy Count Data Call: Summary of 2017 Residential Market Totals," California Department of Insurance, July 24, 2018. <https://www.insurance.ca.gov/0400-news/0200-studies-reports/0300-earthquake-study/upload/EQ2017Summary20180724.pdf>.

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The primary cause of this disparity is that, unlike those other risks, earthquake coverage is not required to secure the collateral of mortgages owned or guaranteed by the government-sponsored enterprises (GSEs) known as Fannie Mae (the Federal National Mortgage Association) and Freddie Mac (the Federal Home Loan Mortgage Corporation), which account for 21 percent and 12 percent, respectively, of the \$14.99 trillion U.S. mortgage debt outstanding.<sup>3</sup>

This exposure should be of concern to policymakers. Ten years ago this month, Fannie Mae and Freddie Mac both were taken into conservatorship by their regulator, the Federal Housing Finance Agency (FHFA), and were granted a \$187 billion capital injection from the U.S. Treasury Department.<sup>4</sup> While each of the GSEs has subsequently repaid its debt to the government, including a 10 percent return on investment,<sup>5</sup> the Treasury continues to provide financial support through senior preferred stock purchase agreements.<sup>6</sup> Currently, the Treasury owns \$200 billion of the GSEs' senior preferred stock.

3. "June 2018 Flow of Funds Report: Mortgage Debt Outstanding (Table 1.54)," Federal Reserve, June 7, 2018. <https://www.federalreserve.gov/data/mortoutstand/current.htm>.

4. Joe Light, "Fannie, Freddie Permitted by U.S. to Keep \$3 Billion Buffers," *Bloomberg*, Dec. 21, 2017. <https://www.bloomberg.com/news/articles/2017-12-21/fannie-and-freddie-permitted-by-u-s-to-keep-3-billion-buffers>.

5. Alex J. Pollock, "Fannie has reached the 10% moment, after all," *R Street Blog*, March 6, 2018. <https://www.rstreet.org/2018/03/06/fannie-has-reached-the-10-moment-after-all>.

6. Glen Bradford, "Entirely Preventable GSE Bailout Not Prevented," *Seeking Alpha*, Feb. 15, 2018. <https://seekingalpha.com/article/4147012-entirely-preventable-gse-bailout-prevented>.

Should a major earthquake strike in the United States—as is inevitable—Fannie Mae and Freddie Mac both would see the destruction of potentially billions of dollars in structures that serve as collateral for their mortgage portfolios and mortgage guarantees. In addition to requiring direct Treasury outlays to the GSEs, the low takeup rate of earthquake insurance also means that taxpayers almost certainly would be asked to shoulder a disproportionate amount of disaster recovery costs through state and federal disaster aid.

The FHFA acknowledges that it does not currently track the GSEs' exposure to uninsured earthquake risk.<sup>7</sup> This paper seeks to quantify the size of that uninsured liability and to propose a means to transfer these implicit taxpayer guarantees to the private sector. Our data analysis comprises three components:

- Using seismic maps published by the U.S. Geological Survey, we identify 249 counties across 21 states that are substantially exposed to the largest earthquake risks.<sup>8</sup>
- Using property-level databases published by the FHFA, we find that, as of 2016, the GSEs held \$355.71 billion of unpaid principal for mortgages in those 249 counties, including \$210.1 billion held by Fannie Mae and \$145.61 billion held by Freddie Mac.<sup>9</sup>
- Making certain base assumptions about the proportion of principal that is attributable to structural value and regional surveys of earthquake insurance takeup, we estimate the total value of uninsured earthquake-exposed collateral held by the GSEs, as of 2016, is \$204.68 billion.

Finally, we propose that Congress move immediately to require a report on risk transfer by the GSEs. Building on their recent credit risk transfer programs, we believe Fannie and Freddie should be required by the FHFA to transfer at least a portion of their earthquake exposure to the private market through a combination of traditional reinsurance transactions and catastrophe bond securitizations.

To finance such transactions, the GSEs should require mortgage originators to assess an appropriate credit charge to

take on mortgages in earthquake-prone regions. To provide incentives for property owners, that charge could be waived for properties that demonstrate continuous earthquake coverage and/or significant investment in seismic retrofitting mitigation.

## TAKEUP RATES FOR EARTHQUAKE INSURANCE

As highlighted in Fannie Mae's selling guide, the GSEs require mortgage loans to include coverage for a broad range of hazards:

Hazard insurance for property securing loans delivered to Fannie Mae must protect against loss or damage from fire and other hazards covered by the standard extended coverage endorsement. The coverage must provide for claims to be settled on a replacement cost basis. Extended coverage must include, at a minimum, wind, civil commotion (including riots), smoke, hail, and damages caused by aircraft, vehicle, or explosion.

Fannie Mae does not accept hazard insurance policies that limit or exclude from coverage (in whole or in part) windstorm, hurricane, hail damages, or any other perils that normally are included under an extended coverage endorsement.<sup>10</sup>

Separately, under terms specified by the Flood Disaster Protection Act of 1973, the GSEs and all other federally related lenders are required to mandate the purchase of flood insurance for mortgages and construction loans located in Special Flood Hazard Areas (SFHAs), as defined by the Federal Emergency Management Agency (FEMA).<sup>11</sup>

However, no similar requirement exists covering insurance for earthquakes. In the absence of a mandate, the high cost of coverage, the low likelihood of disaster and the moral hazard of implicit federal aid for disaster recovery all combine to dissuade U.S. property owners from purchasing earthquake insurance.<sup>12</sup> According to a February 2017 survey by the Insurance Information Institute, only 8 percent of U.S. homeowners nationwide reported purchasing earthquake insurance, either as a separate policy or as an endorsement

7. Melvin L. Watt, "Letter to Rep. Sean Duffy and Sen. Tim Scott," Aug. 17, 2018. <https://www.rstreet.org/wp-content/uploads/2018/09/8-17-18-Response-ltr-to-Congressman-Duffy-re-Earthquake-Risks-1.pdf>.

8. "Earthquake Hazards Program: Information by State/Territory," U.S. Geological Survey. All state maps derived from USGS' 2014 seismic hazard survey except Kansas and Oklahoma, which draw from 2017 surveys that include effects of induced seismicity. <https://earthquake.usgs.gov/earthquakes/byregion>.

9. "Public Use Database - Fannie Mae and Freddie Mac," Federal Housing Finance Agency, 2016 data from the *Single-Family Census Tract File* and *Multi-Family Census Tract File*, accessed Aug. 1 to Aug. 8, 2018. <https://www.fhfa.gov/DataTools/Downloads/Pages/Public-Use-Databases.aspx>.

10. "Selling Guide: Fannie Mae Single Family," Fannie Mae, Jan. 27, 2011, p. 863. <https://www.fanniemae.com/content/guide/sel012711.pdf>.

11. "Mortgage Lender Requiring Flood Insurance," Federal Emergency Management Agency, Sept. 26, 2014. <https://www.fema.gov/faq-details/Mortgage-Lender-Requiring-Flood-Insurance>.

12. Paul R. Kleindorfer and Howard Kunreuther, "Managing Catastrophe Risk: Why Do Homeowners, Insurers, and Banks Not Use Simple Measures to Mitigate the Risk from Hurricanes and Earthquakes?," *Regulation* 23:4 (Jan. 17, 2001), pp. 26-31. [https://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=256755](https://papers.ssrn.com/sol3/papers.cfm?abstract_id=256755).

to their homeowners insurance policy.<sup>13</sup> Takeup rates varied somewhat by region, with 14 percent of homeowners in the West reporting they have earthquake coverage, compared with 7 percent in the Midwest, 6 percent in the South and 6 percent in the Northeast.<sup>14</sup>

In California, which this paper elsewhere shows is home to more than two-thirds of the GSEs' earthquake risk, roughly 75 percent of residential earthquake insurance coverage is provided by the California Earthquake Authority (CEA), a pool of private property insurers that functions as a publicly managed state instrumentality.<sup>15</sup> The CEA was established in 1996, initially to address an availability crisis in the state's homeowners insurance market.<sup>16</sup> Following 1994's Northridge quake, a number of insurers exited or significantly curtailed their underwriting in California, in part due to a 1984 state law that requires homeowners insurers to offer earthquake insurance.<sup>17</sup> Establishment of the CEA allowed that offer requirement to be satisfied by placing an insured with the pool, rather than on the insurer's own balance sheet.

While earthquake insurance penetration in California remains much lower than it was at the time of Northridge, in recent years, the CEA has had some modest success in improving its takeup rate. To do so, it has endeavored to cut rates, offer a broader range of deductible options, doubled the amount of coverage available for contents, quadrupled coverage for additional living expenses and now provides mitigation discounts of up to 20 percent.<sup>18</sup> According to data calls performed by the California Department of Insurance, there were 1.5 million residential earthquake insurance policies written in 2017, representing 13.3 percent of the total 11.6 million residential property insurance policies in the state.<sup>19</sup> That was up from 1.1 million policies and a 10.1 percent take-

up rate in 2013.<sup>20</sup> Alas, even a 13.3 percent takeup rate means the overwhelming majority of earthquake-exposed residential properties lack coverage.

The GSEs do perform structural risk analysis and they recently updated guidance for when a seismic risk assessment must be completed.<sup>21</sup> Unreinforced masonry buildings, buildings constructed on hillsides with slopes that exceed a 30-degree angle and those with a probable maximum loss (PML) of greater than 40 percent are all currently deemed ineligible for securitization.<sup>22</sup> For other concerns that might be uncovered by a seismic risk assessment, insurance is required only until properties make repairs that would bring them into compliance with Fannie and Freddie standards.

By contrast, commercial real estate (CRE) lenders typically require earthquake insurance for properties located in Seismic Zones 3 or 4<sup>23</sup> with a probable maximum loss (PML) of greater than 20 percent. However, according to Kroll Bond Rating Agency, even those more stringent requirements may be insufficient. Analyzing \$30.6 billion of private-label commercial mortgage-backed securities (CMBS) with California collateral issued between 2010 and November 2017, Kroll found that 10 percent of the loans had PMLs between 18 percent and 20 percent, while nearly a quarter had PMLs of 15 percent to 18 percent.<sup>24</sup> Summarizing the report, Kroll wrote:

Although the CRE finance industry has drawn a line in the sand with the greater than 20% threshold, transactions with a sizeable proportion of PMLs that are close to 20% may warrant a closer look by the marketplace, as they can pose additional risk to CMBS trusts. Uninsured assets with higher amounts of damage may be more susceptible to borrower defaults and potentially lead to transaction losses.<sup>25</sup>

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13. "2016 Consumer Insurance Survey - Homeowners Insurance: Understanding, Attitudes and Shopping Practices," Insurance Information Institute, March 1, 2017, p. 6. <https://www.iii.org/sites/default/files/docs/pdf/pulse-wp-020217-final.pdf>.

14. Ibid.

15. Kevin Smith, "Got earthquake insurance? Most don't but guess what? The rates have come down," *Orange County Register*, Jan. 15, 2017. <https://www.ocregister.com/2017/01/15/got-earthquake-insurance-most-dont-but-guess-what-the-rates-have-come-down>.

16. Ian Adams, "Insuring a Way Out: Modernizing the California Earthquake Authority," *R Street Policy Study* No. 32, January 2015, p. 1. <https://www.rstreet.org/2015/01/22/insuring-a-way-out-modernizing-the-california-earthquake-authority>.

17. Ibid.

18. California Earthquake Authority, "CEA Unveils Lower Rates, More Policy Options and Bigger Discounts For Earthquake Insurance," Press Release, Jan. 4, 2016. <https://www.earthquakeauthority.com/Press-Room/Press-Releases/2016/CEA-Unveils-Lower-Rates-More-Policy-Options-and-B>.

19. "Earthquake Premium and Policy Count Data Call: Summary of 2017 Residential Market Totals," California Department of Insurance, July 24, 2018. <https://www.insurance.ca.gov/0400-news/0200-studies-reports/0300-earthquake-study/upload/EQ2017Summary20180724.pdf>.

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20. "Earthquake Premium and Policy Count Data Call: Summary of 2013 Residential Market Totals," California Department of Insurance, June 10, 2014. <http://www.insurance.ca.gov/0400-news/0200-studies-reports/0300-earthquake-study/upload/EQEXP2013.pdf>.

21. Drew H. McCreery, "Fannie Mae Takes Important Step to Align Agency Seismic Requirements," *GlobeSt.com*, Aug. 29, 2017. <https://www.globest.com/sites/partnerESI/2017/08/29/fannie-mae-takes-important-step-to-align-agency-seismic-requirements/?sreturn=20180718155745>.

22. Ibid.

23. According to the 1997 Uniform Building Code, Seismic Zones 3 and 4 are defined as those with a Z factor of greater than 0.3 and 0.4, respectively. Bachman and Bonneville summarize the Z factor as "approximately [...] the effective zero period ground acceleration (in g's) on soft rock that has a 10% probability of exceedance in 50 years." See, Robert E. Bachman and David R. Bonneville, "The Seismic Provisions of the 1997 Uniform Building Code," *Earthquake Spectra* 16:1 (February 2000), p. 86.

24. Kroll Bond Rating Agency, "KBRA Publishes CMBS Research: 'The Earthquake Insurance Divide,'" *Business Wire*, Jan. 2, 2018. <https://www.businesswire.com/news/home/20180102005459/en/KBRA-Publishes-CMBS-Research-%E2%80%9CThe-Earthquake-Insurance>.

25. Ibid.

Were the GSEs to require coverage for earthquakes, as they do for other major natural catastrophe perils, earthquakes would surpass hurricanes as the largest insured peril in the country, with probable maximum loss of \$130 billion, according to analysis by the reinsurance broker Aon Benfield.<sup>26</sup> In a 2011 report to the Federal Reserve Bank of Atlanta, Aon estimated that Fannie Mae and Freddie Mac’s uninsured earthquake risk amounted to a roughly \$100 billion subsidy.<sup>27</sup>

## MAPPING EARTHQUAKE RISKS

In the 21<sup>st</sup> century, the United States has averaged one earthquake each year of magnitude 7.0 to 7.9 on the Richter scale, six of magnitude 6.0 to 6.9, 56 of magnitude 5.0 to 5.9 and thousands of smaller magnitudes.<sup>28</sup> However, the nation has not experienced a truly devastating earthquake since the magnitude 6.7 temblor that struck Northridge, California, in January 1994. As devastating as it was, the Northridge quake would rank only seventh in terms of insured losses if the largest earthquakes in U.S. history were to recur with current exposures (Table 1).

**TABLE 1: ESTIMATED INSURED LOSSES FOR TOP 10 HISTORICAL EARTHQUAKES**

LOCATION	YEAR	MAGNITUDE	2017 INSURED LOSS
San Francisco	1906	7.8	\$71 billion
New Madrid, Mo.	1811-1812	7.7	\$59 billion
Cascadia Subduction Zone	1700	9.0	\$47 billion
San Francisco	1838	7.4	\$31 billion
Charleston, S.C.	1886	7.3	\$30 billion
Northridge, Calif.	1994	6.7	\$15 billion
Hayward, Calif.	1868	7.0	\$15 billion
Wrightwood, Calif.	1812	7.5	\$12 billion
Fort Tejon, Calif.	1857	7.9	\$8 billion
Loma, Prieta, Calif.	1989	6.9	\$4 billion

NOTE: Based on current exposures.

SOURCE: AIR Worldwide, “Top 10 historical earthquakes in the U.S.: What would they cost today?” Verisk Analytics, Nov. 6, 2017. <https://www.verisk.com/insurance/visualize/top-10-historical-earthquakes-in-the-us-what-would-they-cost-today>.

As Table 1 demonstrates, most of the most devastating earthquakes in the nation’s history have been in California.

26. Greg Heerde, “The Insurance Perspective – Discussion of US Earthquake Risk,” Federal Reserve Bank of Atlanta, Aug. 1, 2011, p. 12. <https://www.frbatlanta.org/-/media/documents/news/conferences/2011/real-estate-recovery/heerde.pdf>.

27. Ibid.

28. “Earthquake Statistics: United States Earthquakes 2000–2012,” U.S. Geological Survey, accessed Aug. 18, 2018. <https://earthquake.usgs.gov/earthquakes/browse/stats.php>.

Indeed, most of the state’s 39.5 million residents live within 30 miles of an active fault.<sup>29</sup>

Recent analysis by catastrophe and data analytics firms have projected potential economic losses from a variety of California earthquake scenarios that would dwarf even the 1906 San Francisco quake, which was accompanied by a major fire that ripped through the city. CoreLogic has modeled a potential 8.3 magnitude quake along the 800-mile San Andreas Fault that would affect Northern and Southern California simultaneously, damaging 3.5 million homes and requiring \$289 billion to rebuild, while AIR Worldwide reports it has modeled scenarios that would result in more than \$300 billion in losses.<sup>30</sup>

According to the U.S. Geological Survey’s third Uniform California Earthquake Rupture Forecast, or UCERF3, published in 2015, there is a greater than 99 percent chance the state will experience an earthquake equal to or greater than the 6.7 magnitude Northridge quake at some point in the next 30 years.<sup>31</sup> The odds of a 7.5 magnitude quake, 45 times stronger than Northridge, stand at 48 percent, while there is a 7 percent chance of a quake larger than magnitude 8.0.<sup>32</sup>

But the USGS National Seismic Hazard Model (NSHM) maps demonstrate that earthquake risk is not limited to California. Last updated in July 2014, and scheduled to be updated twice more by 2021,<sup>33</sup> the maps find 42 states with some degree of earthquake, with 16 that have experienced quakes of greater than magnitude 6.0.<sup>34</sup>

Among the most significant of these is the New Madrid fault, which branches through the Mississippi Valley into northeastern Arkansas, southwestern Kentucky, southeastern Missouri and northwestern Tennessee.<sup>35</sup> As shown in Table 1, a series of earthquakes and aftershocks along the fault in late 1811 and early 1812 is regarded to be among the most destructive earthquake events in U.S. history and an

29. KPIX 5, “Despite Quakes, Few California Homeowners Have Earthquake Insurance,” CBS Local, Jan. 5, 2018. <http://cbslocal.com/2018/01/05/few-california-homeowners-have-earthquake-insurance>.

30. Jeff Daniels, “Major quake disaster in Southern California could cause \$300 billion in losses,” *CNBC.com*, Sept. 27, 2017. <https://www.cnbc.com/2017/09/27/major-quake-disaster-in-california-could-cause-300-billion-in-losses.html>.

31. Edward H. Field and 2014 Working Group on California Earthquake Probabilities, “UCERF3: A new earthquake forecast for California’s complex fault system: U.S. Geological Survey 2015–3009,” U.S. Geological Survey, March 9, 2015, p. 4. <https://pubs.usgs.gov/fs/2015/3009/pdf/fs2015-3009.pdf>.

32. Ibid.

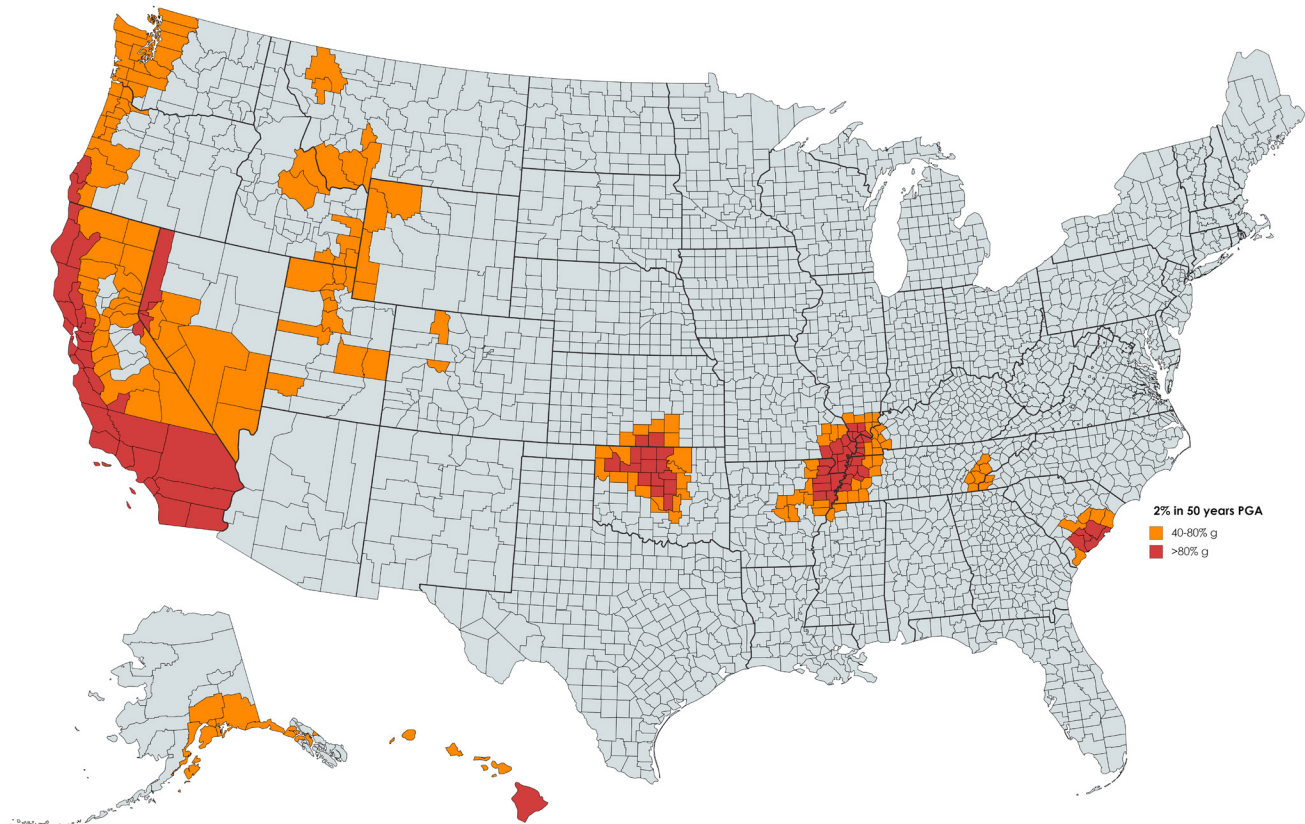
33. “USGS National Seismic Hazard Model Schedule, 2016–2021,” U.S. Geological Survey, accessed Aug. 18, 2018. <https://earthquake.usgs.gov/hazards/images/contrib-sched.png>.

34. “Seismic Hazard Maps and Site-Specific Data,” U.S. Geological Survey, accessed Aug. 18, 2018. <https://earthquake.usgs.gov/hazards/hazmaps>.

35. “Science of the New Madrid Seismic Zone,” U.S. Geological Survey, accessed Aug. 18, 2018. <https://earthquake.usgs.gov/learn/topics/nmsz/1811-1812.php>.



FIGURE I: U.S. COUNTIES EXPOSED TO SUBSTANTIAL EARTHQUAKE RISK



SOURCE: R Street interpretation of USGS National Seismic Hazard Model maps.

equivalent event today could impact the metropolitan areas of Memphis, Tennessee; St. Louis, Missouri; and Paducah, Kentucky, among others.

The most precise tabulation of the seismic risk faced by those mortgages assumed or guaranteed by the GSEs would require matching the longitudinal and latitudinal coordinates of each property to its position on the USGS NSHM maps. Those data are unavailable to us and beyond the scope of this paper. We have instead overlaid the state maps on county jurisdictions to construct a map comprising those counties that are at least partially exposed to seismic risks that exceed a 2 percent chance over the next 50 years of experiencing peak ground acceleration (PGA) of greater than 0.4g, where “g” is equivalent to the Earth’s gravitational force.<sup>36</sup>

For all states except Kansas and Oklahoma, we used the 2014 USGS NSHM maps.<sup>37</sup> For Kansas<sup>38</sup> and Oklahoma,<sup>39</sup> we made use of 2017 updates that include the effects of “induced seismicity,” stemming from deep well wastewater injection processes tied to hydraulic fracturing drilling techniques. In a March 2016 report, the USGS found that many of the more than 3,000 tremors Oklahoma experienced from 2009 through 2014 could be attributed, at least partially, to renewed seismic activity along ancient fault lines by fracking-related processes. The report concluded that, as a result of induced seismicity, the odds of damaging earthquake shaking are now “5–12 percent per year in north-central Oklahoma and southern Kansas, similar to the chance

36. John Douglas, “Earthquake ground motion estimation using strong-motion records: a review of equations for the estimation of peak ground acceleration and response spectral ordinates,” *Earth-Science Reviews* 61:1-2 (April 2003), pp. 43-104. <https://www.sciencedirect.com/science/article/pii/S0012825202001125>.

37. “Earthquake Hazards Program: Information by State/Territory,” U.S. Geological Survey, accessed Aug. 1 to Aug. 3, 2018. <https://earthquake.usgs.gov/earthquakes/byregion>.

38. “Kansas Area Seismicity (1973-8/9/2017; USGS Comcat) and Chance of Damaging Shaking in 2017,” U.S. Geological Survey, Aug. 9, 2017. [https://earthquake.usgs.gov/earthquakes/byregion/kansas/KS\\_damagemap.pdf](https://earthquake.usgs.gov/earthquakes/byregion/kansas/KS_damagemap.pdf).

39. “Oklahoma Area Seismicity (1973-6/29/2017; USGS Comcat) and Chance of Damaging Shaking,” U.S. Geological Survey, June 29, 2017. [https://earthquake.usgs.gov/earthquakes/byregion/oklahoma/OKdamagemap\\_june2017.gif](https://earthquake.usgs.gov/earthquakes/byregion/oklahoma/OKdamagemap_june2017.gif).

TABLE 2: GSE UNPAID PRINCIPAL BALANCE IN EARTHQUAKE-EXPOSED COUNTIES, BY STATE (\$M)

State	FANNIE MAE			FREDDIE MAC			TOTAL GSE		
	>80% g	40-80% g	Total Fannie	>80% g	40-80% g	Total Freddie	>80% g	40-80% g	All
CA	128,806.6	17,182.6	145,989.2	88,188.4	12,024.0	100,212.4	216,995.0	29,206.6	246,201.6
WA	-	22,502.5	22,502.5	-	15,791.8	15,791.8	-	38,294.4	38,294.4
OR	114.1	8,796.1	8,910.2	63.5	6,752.1	6,815.6	177.6	15,548.2	15,725.8
UT	-	8,778.0	8,778.0	-	6,117.4	6,117.4	-	14,895.3	14,895.3
NV	2,361.1	6,331.6	8,692.7	1,572.3	4,595.0	6,167.3	3,933.4	10,926.6	14,860.1
HI	375.4	3,127.6	3,503.0	307.0	2,350.5	2,657.5	682.4	5,478.1	6,160.5
SC	2,092.5	729.8	2,822.4	1,346.8	357.3	1,704.2	3,439.4	1,087.1	4,526.5
TN	82.8	2,531.9	2,614.7	63.2	1,644.8	1,708.0	146.0	4,176.7	4,322.7
OK	1,497.1	357.8	1,854.9	753.7	209.7	963.4	2,250.8	567.5	2,818.3
AR	174.1	737.6	911.6	129.8	601.5	731.2	303.8	1,339.0	1,642.8
AK	-	851.4	851.4	-	648.1	648.1	-	1,499.5	1,499.5
MT	-	681.0	681.0	-	614.7	614.7	-	1,295.7	1,295.7
KS	8.0	601.2	609.2	6.4	457.6	464.0	14.4	1,058.8	1,073.2
MS	-	317.1	317.1	-	227.4	227.4	-	544.5	544.5
ID	-	283.7	283.7	-	144.5	144.5	-	428.3	428.3
WY	-	219.4	219.4	-	178.9	178.9	-	398.3	398.3
CO	-	202.6	202.6	-	123.9	123.9	-	326.6	326.6
KY	49.9	47.5	97.4	49.4	75.1	124.5	99.3	122.6	221.9
MO	51.9	77.1	129.0	30.3	54.7	85.0	82.1	131.8	214.0
IL	13.0	81.8	94.8	11.8	97.8	109.6	24.8	179.6	204.4
NC	-	35.8	35.8	-	22.2	22.2	-	58.0	58.0
TOTALS	135,626.5	74,474.3	210,100.8	92,522.7	53,089.0	145,611.7	228,149.2	127,563.3	355,712.5

SOURCE: R Street analysis of 2016 FHFA Public Use Data

of damage caused by natural earthquakes at sites in parts of California.”<sup>40</sup>

Altogether, we found 249 counties across 21 states that are exposed to the largest earthquake risks. A map of those counties is included as Figure 1, with counties at risk of PGAs of 0.4g to 0.8g shaded in orange and those facing potential PGAs of greater than 0.8g shaded in red. A list of the targeted counties is included as Appendix I to this report.

### GSE MORTGAGES IN EARTHQUAKE-EXPOSED COUNTIES

Under terms of the Housing and Economic Recovery Act of 2008, property-level data about mortgages acquired by Fannie Mae and Freddie Mac are reported to the FHFA and

made available through public-use databases.<sup>41</sup> Making use primarily of 2016 data from the Single-Family Census Tract File and the Multi-Family Census Tract File, we tabulated the total unpaid principal balance on mortgages held or guaranteed by Fannie and Freddie in each of the 249 counties identified in Figure 1 and Appendix I.

Our tallies indicate the GSEs combined to hold or guarantee \$355.71 billion of unpaid principal on mortgages in earthquake-exposed counties, representing 7.3 percent of their combined 2016 mortgage books.<sup>42</sup>

Fannie Mae had \$210.10 billion of unpaid principal balance in earthquake-exposed counties, consisting of \$189.96 billion

40. Mark D. Petersen et al., “2016 one-year seismic hazard forecast for the Central and Eastern United States from induced and natural earthquakes,” U.S. Geological Survey, March 28, 2016. <https://pubs.er.usgs.gov/publication/ofr20161035>.

41. “Public Use Database - Fannie Mae and Freddie Mac,” Federal Housing Finance Agency, accessed Aug. 1 to Aug. 8, 2018. <https://www.fhfa.gov/DataTools/Downloads/Pages/Public-Use-Databases.aspx>.

42. “June 2018 Flow of Funds Report: Mortgage Debt Outstanding (Table 1.54).” <https://www.federalreserve.gov/data/mortoutstand/current.htm>.

associated with single-family properties and \$23.14 billion associated with multi-family properties. Among the single-family mortgages, 65.3 percent of the unpaid principal was located in counties exposed to PGAs of greater than 0.8g, and 34.7 percent was in counties exposed to PGAs of between 0.4g and 0.8g. Among the multi-family mortgages, 58.7 percent of the unpaid principal was located in counties exposed to PGAs of greater than 0.8g, and 41.3 percent was in counties exposed to PGAs of between 0.4g and 0.8g. Together, Fannie had \$135.63 billion of unpaid principal in counties exposed to PGAs of greater than 0.8g, and \$74.47 billion of unpaid principal in counties exposed to PGAs of between 0.4g and 0.8g.

Freddie Mac had \$210.10 billion of unpaid principal balance in earthquake-exposed counties, consisting of \$122.47 billion associated with single-family properties, and \$23.14 billion associated with multi-family properties. Among the single-family mortgages, 64.5 percent of the unpaid principal was located in counties exposed to PGAs of greater than 0.8g, and 35.5 percent was in counties exposed to PGAs of between 0.4g and 0.8g. Among the multi-family mortgages, 58.7 percent of the unpaid principal was located in counties exposed to PGAs of greater than 0.8g, and 41.3 percent was in counties exposed to PGAs of between 0.4g and 0.8g. Together, Freddie had \$92.52 billion of unpaid principal in counties exposed to PGAs of greater than 0.8g, and \$58.09 billion of unpaid principal in counties exposed to PGAs of between 0.4g and 0.8g.

With \$246.20 billion between Fannie Mae and Freddie Mac, California represented more than two-thirds of the total unpaid principal balance in earthquake-exposed counties. As demonstrated in Table 2, Western states dominated the tallies, as California was followed in total exposed principal by Washington State, Oregon, Utah and Nevada.

## ESTIMATING THE GSES' UNINSURED MORTGAGE RISK

The reason to be concerned about uninsured earthquake risk on the GSEs' balance sheet is that the value of a property's improved structures generally represents the bulk of the collateral securing the mortgage. This is of particular concern in "nonrecourse" states in which a mortgage borrower surrenders only the property itself in the event of a default. Of the 21 states in this sample, Alaska, California, Montana, North Carolina, Oregon and Washington State are "nonrecourse" states.<sup>43</sup> In addition, Hawaii and Nevada have laws in place that generally bar mortgage lenders from filing deficiency lawsuits against borrowers.<sup>44</sup>

43. Tong Yob Nam and Seungjoon Oh, "Non-Recourse Mortgage Law and Housing Speculation," SSRN working paper, June 24, 2018, p. 1. <https://ssrn.com/abstract=2316539>.

44. Jason Cheung, "Anti-Deficiency Laws," *LegalMatch Law Library*, May 1, 2018. <https://www.legalmatch.com/law-library/article/anti-deficiency-laws.html>.

Even a catastrophic earthquake, however, would not erase all of the value of property collateral. Except in truly extreme cases, the value of the land itself would remain. Determining the ratio of land value to improvement value is the domain of property appraisers, who employ a variety of formulas to estimate the imputed value of unimproved land. Such ratios can vary significantly from city to city, and even property to property. For the sake of simplicity, this report applies a common rule of thumb: "Lot x 3," which stipulates that the value of an improved lot should generally be about one-third of the improved value of the property.<sup>45</sup>

We also must make assumptions about the penetration of earthquake insurance coverage in areas exposed to substantial earthquake risk. According to S&P Global Market Intelligence statutory insurance data, there were \$2.96 billion of direct premiums for standalone earthquake coverage written in the United States in 2017, with California representing 58 percent of that total.<sup>46</sup> But that figure includes coverage for commercial properties, which aren't eligible for the GSEs, as well as coverage for contents and additional living expenses, which aren't relevant to the GSEs' earthquake risk.

To derive an estimate of the proportion of unpaid principal balance that is insured, we use the regional results reported by the Insurance Information Institute in their February 2017 survey of U.S. homeowners.<sup>47</sup> That is to say, we assume earthquake insurance takeup rates of 14 percent for the 11 states in the West (California, Washington, Oregon, Utah, Nevada, Hawaii, Alaska, Montana, Idaho, Wyoming and Colorado); 7 percent for the three states in the Midwest (Kansas, Missouri and Illinois); and 6 percent for the seven states in the South (South Carolina, Tennessee, Oklahoma, Arkansas, Mississippi, Kentucky and North Carolina). There are no Northeast states in our sample.

By necessity, these estimates are incomplete. Even properties that carry earthquake insurance can potentially have uninsured risk that is transferred to the GSEs. The regional takeup rates also could vary from state to state and among regions within each state.

Surveys of the broad population in each state also may understate takeup rates if earthquake insurance markets are subject to adverse selection, in which an insured's asymmetric information about their own risk profile motivates those who

45. Ardele DellaLoggia, "What percentage of the house is attributed to the land value?" Quora, March 21, 2016. <https://www.quora.com/What-percentage-of-the-house-is-attributed-to-the-land-value>.

46. "Insurance Statutory Market Share tool," S&P Global Market Intelligence, accessed Aug. 18, 2018. <https://platform.mi.spglobal.com/interactivex/MarketShare/ISMarketShare.aspx>.

47. "2016 Consumer Insurance Survey - Homeowners Insurance: Understanding, Attitudes and Shopping Practices," Insurance Information Institute, March 1, 2017, p. 6. <https://www.iii.org/sites/default/files/docs/pdf/pulse-wp-020217-final.pdf>.

face the largest risks to purchase the most insurance.<sup>48</sup> However, the literature on this point suggests any adverse selection effect in the earthquake insurance market is likely to be small. From surveys of California homeowners in the early 1990s, Risa Palm concluded that “the geographic pattern of insurance subscription has consistently been unrelated to relative geophysical risk: those in areas susceptible to high degrees of ground shaking are no more likely to purchase insurance than those in less risky areas.”<sup>49</sup>

Given these assumptions, as demonstrated in Table 3, we estimate total uninsured earthquake risk held by the GSEs to be roughly \$204.68 billion.

**TABLE 3: ESTIMATED UNINSURED EARTHQUAKE RISK OF GSES, 2016 (\$M)**

REGION	TOTAL UNPAID PRINCIPAL	ESTIMATED STRUCTURE VALUE	ESTIMATED VALUE UNINSURED
West	340,086.1	226,724.1	194,982.7
South	14,134.8	9,423.2	8,763.6
Midwest	1,491.6	994.4	934.8
<b>TOTAL</b>			<b>204,681.0</b>

SOURCE: R Street analysis of 2016 FHFA Public Use Data

## TRANSFERRING GSE EARTHQUAKE RISK

In an Aug. 17, 2018 letter to Rep. Sean Duffy (R-Wis.) and Sen. Tim Scott (R-S.C.), responding to questions about how the regulator monitored the GSEs’ earthquake risk, FHFA Director Melvin L. Watt acknowledged that: “Although FHFA does not conduct earthquake exposure studies, the Enterprises conduct regular assessments of risk to various disaster types, including earthquakes.”<sup>50</sup> As members of Congress look to craft a plan that would allow Fannie Mae and Freddie Mac both to exit federal conservatorship,<sup>51</sup> the time has come to address the issue of the GSEs’ uninsured earthquake risk.

One way to do this would be to transfer that risk to the private market through the use of reinsurance, often characterized as “insurance for insurance companies.” Insurers manage their exposure to extreme loss scenarios by ceding

portions of that risk to reinsurers, who take on a diversified pool of uncorrelated risks that vary by geography and line of business.

One model Congress could instruct the GSEs to follow is that of the National Flood Insurance Program (NFIP), which for 50 years has served as the primary source of flood insurance in the United States. After a small test program in 2016, the NFIP entered the reinsurance market in earnest in January 2017, spending \$150 million to cede \$1.042 billion of risk to a consortium of reinsurers.<sup>52</sup> The reinsurance contract was triggered in full as a result of losses from 2017’s Hurricane Harvey. The NFIP subsequently returned to the reinsurance market in January 2018 by purchasing \$1.46 billion of coverage for \$235 million.<sup>53</sup>

In recent years, the GSEs have themselves already sought to tap private reinsurance capital as part of a program of credit risk transfer transactions designed to reduce taxpayers’ exposure to mortgage default risk.<sup>54</sup> Under the contracts, once a layer of losses retained by the GSE is exhausted, reinsurers agree to cover losses on specified pools of loans, up to a set maximum. Fannie Mae recently announced it had closed on its fifth credit insurance risk transfer transaction (CIRT) of 2018, under a program that now provides \$6.9 billion of reinsurance coverage on \$278 billion of loans.<sup>55</sup>

Of course, the size transaction needed to transfer the GSEs’ \$205 billion of uninsured earthquake risk to the reinsurance market would dwarf these earlier transactions. In its 2011 report to the Federal Reserve Bank of Atlanta, the insurance broker Aon Benfield projected the cost to the GSEs of a one-in-250 year earthquake would be roughly \$130 billion and that it would require \$30 billion in annual reinsurance premiums to insure against it.<sup>56</sup>

Until such a program were to be shopped for placement, it is impossible to say what the maximum capacity for U.S. earthquake risk would be or what terms reinsurers would require. One approach would be for the FHFA, as the GSEs’ conservator, to order Fannie and Freddie to solicit bids for earthquake risk transfer transactions. The GSEs could finance those transactions by assessing an appropriate number of basis

48. Pierre-André Chiappori and Bernard Salanié, “Testing for Asymmetric Information in Insurance Markets,” *The Journal of Political Economy* 108:1 (February 2000), pp. 56-78. [http://public.econ.duke.edu/~hf14/teaching/socialinsurance/readings/fudan\\_hsb/Chiappori\\_Salanié00\(2.7\).pdf](http://public.econ.duke.edu/~hf14/teaching/socialinsurance/readings/fudan_hsb/Chiappori_Salanié00(2.7).pdf)

49. Risa Palm, “The Roepke Lecture in Economic Geography Catastrophic Earthquake Insurance: Patterns of Adoption,” *Geosciences Faculty Publications Paper* 9, 1995. [http://scholarworks.gsu.edu/geosciences\\_facpub/9](http://scholarworks.gsu.edu/geosciences_facpub/9)

50. Watt. <https://www.rstreet.org/wp-content/uploads/2018/09/8-17-18-Response-tr-to-Congressman-Duffy-re-Earthquake-Risks-1.pdf>

51. Joe Light, “Fannie-Freddie Overhaul Might Mint Hedge Fund Riches, Losses,” *Bloomberg*, Jan. 4, 2018. <https://www.bloomberg.com/news/articles/2018-01-04/fannie-freddie-overhaul-might-mint-hedge-fund-riches-or-losses>

52. Diane P. Horn and Baird Webel, “The National Flood Insurance Program (NFIP), Reinsurance, and Catastrophe Bonds,” *Congressional Research Service*, April 17, 2018, p. 2. <https://fas.org/sqp/crs/homesec/INI0887.pdf>

53. Ibid.

54. Jonathan B. Glowacki, “Credit risk transfer: Investment comparison,” Milliman, Aug. 7, 2017. <http://www.milliman.com/insight/2017/Credit-risk-transfer-Investment-comparison>

55. Matt Sheehan, “Fannie Mae transfers further \$22bn of loan risk to re/insurers,” *Reinsurance News*, July 27, 2018. <https://www.reinsurancene.ws/fannie-mae-transfers-further-22bn-of-loan-risk-to-re-insurers>

56. Greg Heerde, “The Insurance Perspective – Discussion of US Earthquake Risk,” Federal Reserve Bank of Atlanta, Aug. 1, 2011, p. 12. <https://www.frbatlanta.org/media/documents/news/conferences/2011/real-estate-recovery/heerde.pdf>



points for loans that originate from earthquake-exposed regions. This would obviate the need to require borrowers to obtain earthquake insurance, although it would be wise to credit properties that are insured as incentive for borrowers to maintain coverage. The GSEs also could further tighten their underwriting standards for seismic risks, providing further incentive for homeowners to invest in mitigation.

In the longer term, Congress should examine whether similar requirements are necessary in other federally related lending programs. Taxpayers currently are also on the hook for billions of dollars of uninsured earthquake risk associated with mortgages guaranteed by the Federal Housing Administration, the U.S. Department of Veterans Affairs and the U.S. Department of Agriculture's Farm Service Agency and Rural Housing, not to mention the loans retained by lenders insured by the Federal Deposit Insurance Corp.

## CONCLUSION

Structuring a program to transfer the GSEs' \$205 billion of uninsured earthquake risk off the backs of taxpayers and onto the private market will require careful consideration so as not to lay too onerous a burden on borrowers or to exacerbate problems in markets facing housing supply shortages. But with another Northridge-size quake a near certainty over the next 30 years, and with the potential for losses that could top \$300 billion, the time has come to take a hard look at all of the options. Taxpayers can no longer be asked to bear the risk that hundreds of billions of dollars could come crashing to the ground in the blink of an eye.

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## APPENDIX I: COUNTIES EXPOSED TO EARTHQUAKE

This paper's tabulations of earthquake-exposed mortgages held or guaranteed by Fannie and Freddie draw from U.S. Geological Survey seismic risk maps. They include data drawn from the following counties, each of which are found to have a greater than 2 percent chance over the next 50 years of experiencing peak ground acceleration (PGA) of either greater than 0.8g or between 0.4g and 0.8g.

### *Alaska.*

0.4g-0.8g – Anchorage, Hoonah Angoon, Kenai Peninsula, Kodiak Island, Matanuska-Susitma, Valdez-Cordova, Yakutat..

### *Arkansas.*

>0.8g – Clay, Craighead, Crittenden, Cross, Greene, Mississippi, Poinsett.

0.4g-0.8g – Faulkner, Jackson, Lawrence, Lee, Lonoke, Pulaski, Randolph, St. Francis, White, Woodruff.

### *California*

>0.8g – Alameda, Alpine, Contra Costa, Del Norte, Humboldt, Imperial, Kern, Kings, Lake, Los Angeles, Marin, Mendocino, Monterey, Napa, Orange, Riverside, San Benito, San Bernardino, San Diego, San Francisco, San Luis Obispo, San Mateo, Santa Barbara, Santa Clara, Santa Cruz, Solano, Sonoma, Trinity, Ventura.

0.4g-0.8g – Colusa, El Dorado, Fresno, Glenn, Inyo, Lassen, Merced, Modoc, Mono, Nevada, Placer, Plumas, Sacramento, San Joaquin, Shasta, Sierra., Siskiyou, Stanislaus, Tehama, Tulare, Yolo.

### *Colorado.*

0.4g-0.8g – Pitkin, Routt..

### *Hawaii.*

>0.8g – Hawaii

0.4g-0.8g – Honolulu, Kauai, Maui.

### *Idaho.*

0.4g-0.8g – Bear Lake, Bonneville, Caribou, Custer, Franklin, Lemhi, Oneida.

### *Illinois.*

>0.8g – Alexander, Johnson, Massac, Union.

0.4g-0.8g – Gallatin, Hardin, Jackson, Pope, Saline, Williamson.

*Kansas*

>0.8g – High, Sumner.

0.4g-0.8g – Barber, Butler, Cowley, Kingman, Sedgwick.

*Kentucky*

>0.8g – Ballard, Carlisle, Fulton, Hickman, McCracken.

0.4g-0.8g – Calloway, Crittenden, Graves, Livingston, Lyon, Marshall, Trigg.

*Mississippi*

0.4g-0.8g – DeSoto, Tunica.

*Missouri*

>0.8g – Butler, Dunklin, Mississippi, New Madrid, Pemiscot, Scott, Stoddard.

0.4g-0.8g – Bollinger, Cape Girardeau, Madison, Wayne.

*Montana*

0.4g-0.8g – Beaverhead, Broadwater, Flathead, Gallatin, Lake, Madison.

*Nevada*

>0.8g – Carson City, Douglas, Storey, Washoe.

0.4g-0.8g – Churchill, Clark, Esmeralda, Lincoln, Lyon, Mineral, Nye.

*North Carolina*

0.4g-0.8g – Cherokee, Graham.

*Oklahoma*

>0.8g – Alfalfa, Garfield, Grant, Kay, Kingfisher, Lincoln, Logan, Major, Noble, Oklahoma, Payne, Pottawatomie, Woodward.

0.4g-0.8g – Blaine, Canadian, Creek, Dewey, Ellis, Harper, Okfuskee, Osage, Pawnee, Pontotoc, Seminole, Woods.

*Oregon*

>0.8g – Coos, Curry.

0.4g-0.8g – Benton, Clatsop, Columbia, Douglas, Josephine, Lane, Lincoln, Multnomah, Polk, Tillamook, Washington, Yamhill.

*South Carolina*

>0.8g – Berkeley, Charleston, Colleton, Dorchester.

0.4g-0.8g – Beaufort, Clarendon, Georgetown, Orangeburg, Williamsburg.

*Tennessee*

>0.8g – Crockett, Dyer, Gibson, Lake, Lauderdale, Obion, Tipton.

0.4g-0.8g – Blount, Carroll, Fayette, Hardeman, Haywood, Henry, Knox, Loudon, Madison, McMinn, Monroe, Polk, Shelby, Weakley.

*Utah*

0.4g-0.8g – Cache, Davis, Emery, Grand, Iron, Juab, Rich, Salt Lake, Utah, Weber.

*Washington*

0.4g-0.8g – Clallam, Cowlitz, Grays Harbor, Island, Jefferson, King, Kitsap, Lewis, Mason, Pacific, Pierce, San Juan, Skagit, Snohomish, Thurston, Wahkiakum, Whatcom.\

*Wyoming*

0.4g-0.8g – Lincoln, Park, Teton, Uinta.