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# MITIGATION OF CLIMATE CHANGE RISKS AND REGULATION BY INSURANCE: A FEASIBLE PROPOSAL FOR CHINA

QIHAO HE\*

**Abstract:** Climate change is one of the most fundamental challenges of our time. The extraordinary growth of greenhouse gas (“GHG”) emissions in China represents the single greatest obstacle to global climate change efforts in the coming decades. Meanwhile, China suffers from the adverse consequences of climate change. It has been recognized that two factors may increase climate change risks: (a) the increase in GHG emissions, which will increase the frequency and intensity of climate hazards; and (b) the increase of value-at-risk, such as the increased concentration of the world’s population and property in vulnerable areas. Therefore, mitigation of climate change risk involves not only human intervention to reduce GHG emissions but also prevention of potential losses caused by climate hazards. Among many solutions to risk mitigation, insurance has received increased attention due to its expertise in risk management and regulatory function in influencing policyholders’ behavior. This Article examines the ability of two types of insurance—liability insurance and catastrophe insurance—to regulate and thus help mitigate climate change risks, and considers the potential lessons for China.

## INTRODUCTION

Climate change is one of the most fundamental challenges of our time.<sup>1</sup> The controversy about climate change cuts across scientific theory to litigation. Most scientists who contributed to the United Nations’ Intergovernmental Panel on Climate Change (“IPCC”) 2014 report believe that global

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<sup>1</sup> The terms “climate change” and “global warming” are used interchangeably throughout this Article. Climate change is considered the phenomenon by which human activity has altered the Earth’s atmosphere. See JOHN J. DELANEY ET AL., *HANDLING THE LAND USE CASE: LAND USE LAW, PRACTICE & FORMS* § 42(1) (3d ed. 2016).

climate change is occurring on a significant scale.<sup>2</sup> Climate change “leads to changes in the frequency, intensity, spatial extent, duration, and timing of extreme weather and climate events, and can result in unprecedented extreme weather and climate events.”<sup>3</sup> It is quite plausible that damages resulting from climate change might mount as high as \$1 trillion annually by 2040.<sup>4</sup> In *Massachusetts v. Environmental Protection Agency*,<sup>5</sup> the Supreme Court of the United States for the first time recognized that greenhouse gases (“GHGs”) could have “a significant, disruptive impact on our climate.”<sup>6</sup>

China is the world’s leading emitter of GHGs, having surpassed the United States in 2006.<sup>7</sup> As a result, “[t]he extraordinary growth of greenhouse gas emissions in China represents the single greatest challenge to global climate change efforts in coming decades.”<sup>8</sup> As Alex Wang has noted: “Without significant contribution from China, efforts to find a solution to global climate change are unlikely to succeed.”<sup>9</sup> Meanwhile, China suffers from the adverse consequences of climate change, and the impact has closely

<sup>2</sup> INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2014: IMPACTS, ADAPTATIONS, AND VULNERABILITY 1133, 1136 (2014), <http://www.ipcc.ch/report/ar5/wg2/> [<https://perma.cc/C5JD-SS7K>]. This report asserts that “the effects of climate change are already occurring on all continents and across the oceans.” See *Climate Change Effects Already Seen on All Continents, All Oceans*, EARTH SKY (Mar. 31, 2014), <http://earthsky.org/science-wire/climate-change-effects-already-seen-on-all-continents-all-oceans> [<https://perma.cc/2LAG-VWXZ>]. It was produced by “[a] total of 309 coordinating lead authors . . . and review editors, drawn from 70 countries . . .” *Id.* It also “enlisted the help of 436 contributing authors, and a total of 1,729 expert and government reviewers.” *Id.* In addition, “an extensive dataset of 1,372 climate researchers and their publication and citation data . . . show[s] that . . . 97–98% of the climate researchers most actively publishing in the field . . . support the tenets of [anthropogenic climate change] outlined by the Intergovernmental Panel on Climate Change . . .” See William R.L. Anderegg et al., *Expert Credibility in Climate Change* 107 PNAS 12,107, 12,107 (2010).

<sup>3</sup> INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, MANAGING THE RISKS OF EXTREME EVENTS AND DISASTERS TO ADVANCE CLIMATE CHANGE ADAPTATION 7, 3–21 (Christopher B. Field et al. eds., 2012) [hereinafter IPCC RISK REPORT], [https://www.ipcc-wg2.gov/SREX/images/uploads/SREX-All\\_FINAL.pdf](https://www.ipcc-wg2.gov/SREX/images/uploads/SREX-All_FINAL.pdf) [<https://perma.cc/D3P3-YANF>].

<sup>4</sup> U. N. ENV’T PROGRAMME FIN. INITIATIVE CLIMATE CHANGE WORKING GRP., ADAPTATION AND VULNERABILITY TO CLIMATE CHANGE: THE ROLE OF THE FINANCE SECTOR 14 (2006), [http://www.unepfi.org/fileadmin/documents/CEO\\_briefing\\_adaptation\\_vulnerability\\_2006.pdf](http://www.unepfi.org/fileadmin/documents/CEO_briefing_adaptation_vulnerability_2006.pdf) [<https://perma.cc/9NP4-QUQX>] (“[I]t seems very likely that the [sic] there will be a ‘peak’ year that will record costs over 1 trillion USD before 2040.”).

<sup>5</sup> 549 U.S. 497 (2007).

<sup>6</sup> Joseph MacDougald & Peter Kochenburger, *Insurance and Climate Change*, 47 J. MARSHALL L. REV. 719, 720 (2013).

<sup>7</sup> JOS G.J. OLIVIER ET AL., PBL NETH. ENVTL. ASSESSMENT AGENCY, TRENDS IN GLOBAL CO<sub>2</sub> EMISSIONS: 2012 REPORT 1, 6 (2012), <http://edgar.jrc.ec.europa.eu/CO2REPORT2012.pdf> [<https://perma.cc/DG5C-T94H>].

<sup>8</sup> Alex Wang, *Climate Change Policy and Law in China*, in OXFORD HANDBOOK OF INTERNATIONAL CLIMATE CHANGE LAW (Cinnamon P. Carlarne et al. eds., 2016) (forthcoming).

<sup>9</sup> *Id.*

followed the global trend.<sup>10</sup> Floods, heavy rainfall, landslides, and many other climate hazards are likely to increase dramatically in China.<sup>11</sup> The increasing frequency and intensity of catastrophe disasters will no doubt impede the already vulnerable socioeconomic development of China.<sup>12</sup>

It has been recognized that two factors may increase climate change risks: (a) the rising GHG emissions, which will increase the frequency and intensity of climate hazards,<sup>13</sup> and (b) the accumulation of value-at-risk, such as the concentration of the world's population and property, in vulnerable areas.<sup>14</sup> Therefore, mitigation of climate change risk involves not only human intervention to reduce GHG emissions but also prevention of potential losses caused by climate hazards. Among the many proposed solutions to risk mitigation, insurance has received increased attention due to its emphasis on risk management and its regulatory function in influencing policyholders' behavior. In other words, insurance could not only compensate the victims of climate hazards but also reduce climate change risks.

This Article examines the ability of two types of insurance—liability insurance and catastrophe insurance—to regulate and thus help mitigate climate change risks, including risks from rising GHG emissions, and considers the lessons for China. Part I examines the connection between climate change and insurance.<sup>15</sup> Part II focuses specifically on the insurability of cli-

<sup>10</sup> QIN DAHE ET AL., ASSESSMENT OF CLIMATE AND ENVIRONMENT CHANGES IN CHINA (I): CLIMATE AND ENVIRONMENT CHANGES IN CHINA AND THEIR PROJECTIONS 1, 4–9 (2005).

<sup>11</sup> “[B]ased on the regression analysis of natural disaster occurrence and average global temperature from 1980 to 2010, the frequency of epidemics, extreme temperature, flood and storm was estimated to increase by 506 times per year if the average global temperature increases by 1°C.” Sha Chen et al., *Natural Disasters in China: 1900–2011*, 69 NAT. HAZARDS 1597, 1598 (2013).

<sup>12</sup> See *id.* at 1597–98.

<sup>13</sup> “[S]cientific consensus has established with significant confidence a link between CO<sub>2</sub> emissions and human-induced global warming.” Daniel J. Grimm, Note, *Global Warming and Market Share Liability: A Proposed Model for Allocating Tort Damages Among CO<sub>2</sub> Producers*, 32 COLUM. J. ENVTL. L. 209, 211–12 (2007). Similar statements have been confirmed by the United States Supreme Court's decision in *Massachusetts v. Environmental Protection Agency*. See 549 U.S. 497, 504–05 (2007). “[A] doubling of CO<sub>2</sub> may increase the frequency of the most intense cyclones, although attribution of the 30-year trends to global warming would require a longer global data record . . . .” P.J. Webster et al., *Changes in Tropical Cyclone Number, Duration, and Intensity in a Warming Environment*, 309 SCI. 1844, 1846 (2005) (internal citation omitted); see also Thomas R. Knutson & Robert E. Tuleya, *Impact of CO<sub>2</sub>-Induced Warming on Simulated Hurricane Intensity and Precipitation: Sensitivity to the Choice of Climate Model and Convective Parameterization*, 17 J. CLIMATE 3477, 3481 (2004).

<sup>14</sup> Value-at-risk refers to the increase in the value, such as asset values, exposed to natural hazards. See Arthur Charpentier, *Insurability of Climate Risks*, 33 GENEVA PAPERS ON RISK & INS. 91, 91–109 (2008), [https://www.genevaassociation.org/media/246144/ga2008\\_gp33\(1\)\\_charpentier.pdf](https://www.genevaassociation.org/media/246144/ga2008_gp33(1)_charpentier.pdf) [<https://perma.cc/6GXL-99E4>]; Howard C. Kunreuther & Erwann O. Michel-Kerjan, *Climate Change, Insurability of Large-Scale Disasters, and the Emerging Liability Challenge*, 155 U. PA. L. REV. 1795, 1805, 1807 (2007).

<sup>15</sup> See *infra* notes 19–45 and accompanying text.

mate-related liability risk and catastrophe risk, respectively.<sup>16</sup> Part III explores why regulation by liability insurance, whose appropriateness relies on the efficiency of tort-based climate change litigation for loss mitigation, is infeasible, especially in China.<sup>17</sup> Finally, Part IV compares the liability insurance model with the catastrophe insurance model and then proposes a catastrophe-insurance-based private-public partnership for China.<sup>18</sup>

## I. CLIMATE CHANGE AND INSURANCE

### A. *The Impact of Climate Change on the Insurance Industry*

Inevitably, climate change does and will continue to affect the insurance industry, whose function is to shield individuals and businesses from risk.<sup>19</sup> The American International Group (“AIG”), Swiss Re, Lloyd’s of London, and other leading insurers and reinsurers all identify climate change as a major threat to global risk management.<sup>20</sup> Major types of insurance products have been affected by climate change. The most widely recognized impact is catastrophic property losses caused by extreme weather hazards.<sup>21</sup> The level of economic losses, including damages to buildings, houses, factories, and business interruption, has increased dramatically due to both climate change and an increasing concentration of the world’s population in vulnerable areas.<sup>22</sup> For example, in 1992, Hurricane Andrew caused havoc for catastrophe insurers.<sup>23</sup> The total paid claims were \$15.5 billion; more than ten insurers went into insolvency.<sup>24</sup> Some property insurers who suffered from extensive

<sup>16</sup> See *infra* notes 46–73 and accompanying text.

<sup>17</sup> See *infra* notes 74–118 and accompanying text.

<sup>18</sup> See *infra* notes 119–151 and accompanying text.

<sup>19</sup> James M. Davis, *Global Warming Litigation—Implications for Insurance Coverage*, in NEW APPLEMAN ON INSURANCE: CURRENT CRITICAL ISSUES IN INSURANCE LAW 1, 1 (2007).

<sup>20</sup> AIG’S POLICY AND PROGRAMS ON ENVIRONMENT AND CLIMATE CHANGE 1 (n.d.), [http://media.corporate-ir.net/media\\_files/irol/76/76115/aig\\_climate\\_change\\_updated.pdf](http://media.corporate-ir.net/media_files/irol/76/76115/aig_climate_change_updated.pdf) [<https://perma.cc/CN65-WVUW>]; see Trevor Maynard, *Climate Change: Impacts on Insurers and How They Can Help with Adaptation and Mitigation*, 33 GENEVA PAPERS ON RISK & INS. 140, 140 (2008), [https://www.genaassociation.org/media/246394/ga2008\\_gp33\(1\)\\_maynard.pdf](https://www.genaassociation.org/media/246394/ga2008_gp33(1)_maynard.pdf) [<https://perma.cc/F6FU-ZAAC>].

<sup>21</sup> Christina Ross et al., *Limiting Liability in the Greenhouse: Insurance Risk-Management Strategies in the Context of Global Climate Change*, 26A STAN. ENVTL. L.J. 251, 252 (2007).

<sup>22</sup> See Kunreuther & Michel-Kerjan, *supra* note 14, at 1806.

<sup>23</sup> RAWLE O. KING, CONG. RES. SERV., HURRICANES AND DISASTER RISK FINANCING THROUGH INSURANCE: CHALLENGES AND POLICY OPTIONS, at CRS-4 to -5 (2005), <http://www.au.af.mil/au/awc/awcgate/crs/rl33086.pdf> [<https://perma.cc/2ZZM-TDGL>].

<sup>24</sup> LYNNE MCCHRISTIAN, INS. INFO. INST., HURRICANE ANDREW AND INSURANCE: THE ENDURING IMPACT OF AN HISTORIC STORM 2, 5 (2012), [http://www.iii.org/sites/default/files/paper\\_HurricaneAndrew\\_final.pdf](http://www.iii.org/sites/default/files/paper_HurricaneAndrew_final.pdf) [<https://perma.cc/3M3G-RPMW>]; U.S. GOV’T ACCOUNTABILITY OFFICE, GAO-02-941, CATASTROPHE INSURANCE RISK: THE ROLE OF RISK-LINKED SECURITIES AND FACTORS AFFECTING THEIR USE 11 (2002).

catastrophe loss claims even filed lawsuits against the state for its negligence in preparing for and mitigating the damage from climate-change-related weather events.<sup>25</sup>

Similarly, impacts of climate change on the liability insurance sector are beginning to appear.<sup>26</sup> Liability claims related to climate change are already being filed.<sup>27</sup> Hundreds of climate change cases have been brought in the courts of eighteen countries on six continents; this litigation is projected to impose material costs on liability insurers.<sup>28</sup> Additionally, climate change presents public health concerns relevant to life-health insurance lines. For example, extreme weather may cause possible outbreaks of respiratory and infectious diseases that increase the severity of personal risks including illness, disability, and death.<sup>29</sup>

Among different lines of insurance products, non-life insurers have to make much more effort than life insurers to address the impacts of climate change.<sup>30</sup> Litigation over property losses and liability, especially the damages to structures caused by extreme weather hazards, receives the most attention.<sup>31</sup> Meanwhile, much less consideration has been given to life

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<sup>25</sup> See *Climate Change: Insurance Issues*, INS. INFO. INST. (Sept. 2014), <http://www.iii.org/issue-update/climate-change-insurance-issues> [<https://perma.cc/EF3D-WH7C>]. For example, “[i]n May 2014, subsidiaries of Farmers Insurance filed class-action lawsuits against a number of communities in the Chicago area, arguing that they had not done enough to prepare for last year’s heavy rains and widespread flooding, which could have been anticipated due to global warming.” *Id.* They argued that extensive property damages were caused by these extreme weather hazards. See *id.*

<sup>26</sup> The relevant categories of liability insurance surrounding climate change impact include commercial general liability, product liability, environmental liability, professional liability (directors’ and officers’ liability insurance), political risk liability concerning new government policies, and personal and commercial vehicle liability. See Ross et al., *supra* note 21, at 282–83.

<sup>27</sup> See *id.* at 258.

<sup>28</sup> See JACQUELINE PEEL & HARI M. OSOFSKY, *CLIMATE CHANGE LITIGATION 1–2* (James Crawford & John S. Bell eds., 2015).

<sup>29</sup> Sean B. Hecht, *Climate Change and the Transformation of Risk: Insurance Matters*, 55 UCLA L. REV. 1559, 1575–76 (2008).

<sup>30</sup> Non-life insurers develop modeling techniques that enable them to predict the increasingly visible signs of climate change risk. For example, by using state-of-the-art modeling techniques, several important findings are released on the financial impact on insured risk of “precipitation-induced inland floods in Great Britain, winter windstorms in the United Kingdom, and typhoons in China.” Peter Daley et al., *The Financial Risks of Climate Change 3* (Ass’n of British Insurers, ABI Research Paper No. 19, 2009). Life insurers may not be well prepared for the dramatic changes in mortality and morbidity relating to illness and death caused by extreme weather. See Hsin-Chun Wang, *Adaptation to Climate Change and Insurance Mechanism: A Feasible Proposal Based on a Catastrophe Insurance Model for Taiwan*, 9 NAT’L TAIWAN U. L. REV. 317, 322 (2014).

<sup>31</sup> For example, “U.S.-based insurers’ knowledge of climate change impacts has been largely focused on property and casualty (P&C) insurance lines,” especially on “damage to fixed structures.” See Ross et al., *supra* note 21, at 257–58. In addition, most climate change litigations involve non-life insurers rather than life insurers. See PEEL & OSOFSKY, *supra* note 28, at 1–4.

exposures.<sup>32</sup> Therefore, this Article will mainly discuss mitigation of climate change risks through liability insurance and catastrophe insurance.

### *B. Why Insurance Could Theoretically Mitigate Climate Change Risks*

As a well-known professional risk management mechanism, insurance plays an important role in mitigating both property and liability risks.<sup>33</sup> For example, a 2012 report of the IPCC identified insurance as a risk mitigation tool for extreme weather events.<sup>34</sup> Because they assume both liability and property risks, in theory insurers have the incentives and the capacity to mitigate risks and the resulting losses.<sup>35</sup> Scholars of regulation-by-insurance, also called insurance-as-governance, propose several theoretical explanations for insurance's risk mitigation function.<sup>36</sup>

Some scholars assert that, in the modern state, insurers often perform behavior-control functions and create incentives for policyholders to mitigate risks.<sup>37</sup> For example, through insurance rate classification, liability insurers can charge experience-rated premiums and thus induce policyholders to "behave more carefully than they would otherwise."<sup>38</sup> In practice, insurance laws' reluctance to prohibit rate classification based on controllable characteristics supports insurers' behavior-control functions. Some scholars claim that, compared to the state, insurers have the capacity to manage moral hazard because of both superior information and competition.<sup>39</sup> Besides *ex post*

<sup>32</sup> Ross et al., *supra* note 21, at 279–81. Life exposures generally refer to personal risks like illness, disability, and death. See Wang, *supra* note 30, at 322.

<sup>33</sup> Howard C. Kunreuther, *Linking Insurance and Mitigation to Manage Natural Disaster Risk*, in HANDBOOK OF INSURANCE 593, 594 (Georges Dionne ed., 2000).

<sup>34</sup> IPCC RISK REPORT, *supra* note 3, at 35, 55.

<sup>35</sup> "If an insurer can lower its premiums by lowering its risk of paying claims, it can undercut its competitors by charging lower premiums, thereby attracting more business. Marketplace considerations, rather than altruism, drive insurers to reduce risk." See John A. Cogan Jr., *The Uneasy Case for Food Safety Liability Insurance*, 81 BROOKLYN L. REV. (forthcoming 2016). With respect to capacity, insurers have many techniques to reduce risk, and the consensus is that these techniques work reasonably well. See Tom Baker & Peter Siegelman, *The Law and Economics of Liability Insurance: A Theoretical and Empirical Review*, in RESEARCH HANDBOOK IN THE ECONOMICS OF TORT 169, 169 (Jennifer Arlen ed., 2013).

<sup>36</sup> See *infra* notes 37, 39–40 and accompanying text.

<sup>37</sup> Kenneth S. Abraham, *Four Conceptions of Insurance*, 161 U. PA. L. REV. 653, 685 (2013); Tom Baker & Jonathan Simon, *Embracing Risk*, in EMBRACING RISK: THE CHANGING CULTURE OF INSURANCE AND RESPONSIBILITY 1, 12–13 (Tom Baker & Jonathan Simon eds., 2002); Jeffrey W. Stempel, *The Insurance Policy as Social Instrument and Social Institution*, 51 WM. & MARY L. REV. 1489, 1498–1501 (2010).

<sup>38</sup> Abraham, *supra* note 37, at 685; see, e.g., *Can You Afford Not to Be in Good Hands?*, ALL-STATE, <https://www.allstate.com/auto-insurance/auto-insurance-comparison.aspx> [https://perma.cc/2AFM-W8VC].

<sup>39</sup> Moral hazard is the tendency to exercise less care to avoid losses. See Tom Baker, *On the Genealogy of Moral Hazard*, 75 TEX. L. REV. 237, 239 (1996). By "utilizing the methodologies of

indemnification, insurance uses regulatory techniques such as risk-based premiums, deductibles, exclusions, and loss-reduction services, to give policyholders the incentive to reduce risks and invest in prevention measures.<sup>40</sup>

Theoretically, risk-based pricing is regarded as the central approach of insurers to risk mitigation. Insurers' premium-setting process gives policyholders the financial incentive to undertake mitigation measures. In theory, the insurance premium is based on the expected overall losses, derived by multiplying loss probability by loss severity.<sup>41</sup> Reducing either the probability or the severity of loss may lower the premium. As long as such reduction cost is lower than the discount of the premium, policyholders would likely undertake mitigation.<sup>42</sup> If the loss probability and loss severity are too high, however, insurers may refuse to underwrite in the first place.<sup>43</sup>

What has been explained previously about insurance in general also applies to liability and catastrophe insurance. In the case of liability insurance, which is designed to defend and indemnify insured emitters of GHGs in climate-change-related tort lawsuits, insurers could charge a lower premium for the insured emitter who reduces GHG emissions, or refuse to underwrite that risk if the insured is emitting too much. In the case of catastrophe insurance, which is designed to compensate victims of extreme weather hazards, insurers could, through higher premiums, deter the insured from residing in higher risk areas as compared to lower risk areas.<sup>44</sup> Therefore, theoretically, insurance could help reduce the GHG emissions, reduce value-at-risk, and thus realize the mitigation of climate change risks.

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actuarialism, private contracting, and ex post claim investigation," insurers can easily collect customer's purchasing information, thereby replacing government. See Omri Ben-Shahar & Kyle D. Logue, *Outsourcing Regulation: How Insurance Reduces Moral Hazard*, 111 MICH. L. REV. 197, 201 (2012). "It is generally believed that insurance markets tend to be highly competitive with respect to price." See *id.* at 201 n.11 (citing Daniel Schwarcz, *Regulating Consumer Demand in Insurance Markets*, 3 ERASMUS L. REV. 23, 43 (2010)).

<sup>40</sup> Tom Baker & Rick Swedloff, *Regulation by Liability Insurance: From Auto to Lawyers Professional Liability*, 60 UCLA L. REV. 1412, 1416–23 (2013); Ben-Shahar & Logue, *supra* note 39, at 203–17; Steven Shavell, *On the Social Function and Regulation of Liability Insurance*, 25 GENEVA PAPERS ON RISK & INS. 166, 168–70 (2000), [http://www.law.harvard.edu/faculty/shavell/pdf/25\\_Geneva\\_Papers\\_Risk\\_Insur\\_166.pdf](http://www.law.harvard.edu/faculty/shavell/pdf/25_Geneva_Papers_Risk_Insur_166.pdf) [<https://perma.cc/8H93-XDLT>]; Haitao Yin et al., *Risk-Based Pricing and Risk-Reducing Effort: Does the Private Insurance Market Reduce Environmental Accidents?*, 54 J.L. & ECON. 325, 328–29 (2011).

<sup>41</sup> Peter Molk, *Private Versus Public Insurance for Natural Hazards: Individual Behavior's Role in Loss Mitigation*, in RISK ANALYSIS OF NATURAL HAZARDS 265, 265–77 (Paolo Gardoni et al. eds., 2015).

<sup>42</sup> *Id.*

<sup>43</sup> This also serves as a gatekeeping function. See Tom Baker & Thomas O. Farrish, *Liability Insurance & the Regulation of Firearms*, in SUING THE GUN INDUSTRY: A BATTLE AT THE CROSSROADS OF GUN CONTROL AND MASS TORTS 292, 294–95 (Timothy D. Lytton ed., 2008).

<sup>44</sup> Swenja Surminski, *The Role of Insurance in Reducing Direct Risk: The Case of Flood Insurance*, 7 INT'L REV. ENVTL. & RESOURCE ECON. 241, 264 (2013).

While promising in theory, this is not always true in practice. Whether insurance could send these valuable price signals for climate change risk mitigation depends on a number of practical issues. The following discussion will examine how liability insurance and catastrophe insurance function as risk mitigation in practice.<sup>45</sup>

## II. INSURABILITY OF CLIMATE CHANGE RISKS

Before answering the question of how insurance can function as risk mitigation, as a threshold matter, we need to revisit the issue of whether climate change risks are insurable, which concerns the willingness and affordability of insurance companies to insure climate-related liability and catastrophe risk.<sup>46</sup>

### A. Insurability of Climate Change Liability Risk

People worry that climate change claims might be the “next asbestos” for insurers. Asbestos claims were some of the first mass tort cases to push the boundaries of liability insurance insurability and coverage.<sup>47</sup> Many describe climate change liability risk as an “emerging risk.” When insurers initially underwrote climate change risks, they were perhaps not aware of all the potential impacts. But now those risks are perceived as potentially significant, and even possibly the greatest risk to the property/casualty insurance industry.<sup>48</sup> In defining whether climate change liability risks are insurable, the insurance literature identifies certain basic requirements to be considered:

- (1) Actuarial estimation requires that the insurers can identify, quantify, and estimate the frequency and severity of risks and the resulting losses.
- (2) A causal relationship requires that the causes of losses must be directly assignable and allocable to the insured as the subject of liability.
- (3) Randomness requires that the materialization of the risk must be random, unintended, and unexpected.<sup>49</sup>

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<sup>45</sup> See *infra* notes 46–73 and accompanying text.

<sup>46</sup> Wang, *supra* note 30, at 323.

<sup>47</sup> TOM BAKER & KYLE D. LOGUE, INSURANCE LAW AND POLICY: CASES AND MATERIALS 330 (Vicki Been et al. eds., 2013).

<sup>48</sup> *Climate Change No. 1 in Top 10 Risks Facing the Insurance Industry*, INS. J. (Mar. 12, 2008), <http://www.insurancejournal.com/news/national/2008/03/12/88138.htm> [<https://perma.cc/47HM-5DVT>].

<sup>49</sup> SWISS RE, EMERGING RISKS: A CHALLENGE FOR LIABILITY UNDERWRITERS 33 (2009); Baruch Berliner, *Large Risks and Limits of Insurability*, 10 GENEVA PAPERS ON RISK & INS. 313–

While these requirements present challenges for liability insurers, arguments that climate change liability risk is uninsurable may not always be convincing.

First, liability insurers may worry that climate change presents uncertainty as to the intensity and the frequency of natural disasters<sup>50</sup> and that increasing litigations could cause substantial financial losses to insurers because insurers' duty to defend<sup>51</sup> is much broader than their duty to indemnify, at least in the United States; however, "neither the size of the risk" nor potential loss estimates have prevented successful insurance operations in the past.<sup>52</sup> Looking "back at insurance history, there are plenty of examples of insurance against [catastrophe] losses that the insurers could not predict in advance . . . ." <sup>53</sup> Examples include commercial satellite insurance and commercial aircraft insurance. These insurance products both involve huge losses, and at the initial stage of underwriting, insurers had no historical data to assess the intensity and the frequency of losses.<sup>54</sup> Even considering that these risks are still smaller than those from climate change, insurance history is full of what people in the insurance trade call *assessment insurance*.<sup>55</sup> Assessment insurance allows insurers to avoid the same budget constraints they used to encounter, and thereby lessens the fear of uncertainty.<sup>56</sup>

In addition to some degree of certainty regarding the size of the risk and potential loss, for a claim to be insurable there must be an actual causal re-

29 (1985) (analyzing the limits to insurability of a given risk); see also Charpentier, *supra* note 14, at 91–109; Wang, *supra* note 30, at 324.

<sup>50</sup> "[T]he uncertainty of climate change risk will significantly affect the insurability of liability relating to tort litigation . . ." Wang, *supra* note 30, at 325. It is inevitable for liability insurers to pay enormous litigation costs for the insured. See *id.* at 324–25.

<sup>51</sup> In liability insurance policy, "the duty to defend" is an essential part which means that the insurers agreed not only to pay tort judgments against the policyholder but also to defend the lawsuits brought by plaintiffs against the policyholder even if the suit was groundless, false, or fraudulent. In this sense, liability insurance in effect became "litigation insurance." See Jeffrey W. Stempel, *Insurance and Climate Change Litigation*, in ADJUDICATING CLIMATE CHANGE: STATE, NATIONAL AND INTERNATIONAL APPROACHES 230, 235 (William C.G. Burns & Hari M. Osofsky eds., 2009).

<sup>52</sup> Dwight Jaffee & Thomas Russell, *Catastrophe Insurance, Capital Markets, and Uninsurable Risks*, 64 J. RISK & INS. 205, 207 (1997).

<sup>53</sup> Tom Baker, *Embracing Risk, Sharing Responsibility*, 56 DRAKE L. REV. 561, 569 (2008).

<sup>54</sup> See KARL H. BORCH, *ECONOMICS OF INSURANCE* 315 (C.J. Bliss & M.D. Intriligator eds., 1990); Jaffee & Russell, *supra* note 52, at 205, 207.

<sup>55</sup> See Baker, *supra* note 53, at 569 ("With assessment insurance, the insurer has the ability to come back and collect more after a loss to help people who need it if the insurance fund runs dry.").

<sup>56</sup> For example, consider Florida's Citizens Property Insurance Corporation. "Citizens can secure emergency funding for catastrophic losses that exceed its own reserves" under the assessment process. See Omri Ben-Shahar & Kyle D. Logue, *The Perverse Effects of Subsidized Weather Insurance* 15 (U. Mich. Law Sch. Law & Econ. Working Papers, Paper No. 111, 2015), [http://repository.law.umich.edu/cgi/viewcontent.cgi?article=1221&context=law\\_econ\\_current](http://repository.law.umich.edu/cgi/viewcontent.cgi?article=1221&context=law_econ_current) [<https://perma.cc/H7CE-6VRU>]. Citizens could impose a tax on all Citizens' policyholders. "Part of this assessment/tax is collected up front, and part is spread out over a number of years, until the deficit is paid." See *id.*

lationship between the greenhouse gases (“GHGs”) emitted by the insured and the resulting property damages or bodily injuries. If not, the liability insurer has a strong argument for denying coverage. Causal uncertainty between climate change and the GHG emitters will affect the efficiency of tort-based climate change litigation.<sup>57</sup> It is still a matter of debate whether large GHG emitters—such as fossil fuel companies, power plants, and automobile manufacturers—can be liable for the losses of extreme weather events and sea level rise as the potential tortfeasors.<sup>58</sup> Considering this causal uncertainty, climate change liability risk cannot be considered entirely uninsurable because the probability of an insured loss is lower.

Another obstacle to insurability is that the timing, magnitude, or location of extreme weather events cannot be known precisely in advance, and thus there might be both a demand for such insurance and willingness by insurers to underwrite such risks. The randomness of the climate hazards also means that insureds have no control over the hazard creating such liability risk, which speaks to the problems of moral hazard and adverse selection.<sup>59</sup> Moral hazard and adverse selection are generally caused by asymmetric information, which exist in the situation where one party has more or better information than the other in the transaction.<sup>60</sup> In cases of climate hazards, however, insureds have no more information than insurers.

Retroactive liability—which refers to the fact that in the interval between the original tort and the claim for damages the standard of care applied by the courts may change—may also endanger the insurability of long-tail risks.<sup>61</sup> Indeed, a state court might require insurers (*ex post*) to extend coverage or pay out based on retroactive liability, which some jurisdictions have adopted for environment liabilities.<sup>62</sup> Some courts have equated the

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<sup>57</sup> See *infra* notes 76–85 and accompanying discussion.

<sup>58</sup> David A. Grossman, *Warming Up to a Not-So-Radical Idea: Tort-based Climate Change Litigation*, 28 COLUM. J. ENVTL. L. 1, 22–33 (2003).

<sup>59</sup> Jaffee & Russell, *supra* note 52, at 206. Adverse selection means that those with the highest risk are most likely to buy the insurance. See VÉRONIQUE BRUGGEMAN, COMPENSATING CATASTROPHE VICTIMS: A COMPARATIVE LAW AND ECONOMICS APPROACH 64–66 (Kurt Deketelaere ed., 2010).

<sup>60</sup> BRUGGEMAN, *supra* note 59, at 64–66.

<sup>61</sup> Michael Faure & Paul Fenn, *Retroactive Liability and the Insurability of Long-Tail Risks*, 19 INT’L REV. L. & ECON. 487, 490–93 (1999). Simply put, long-tail risk refers to the risks arising out of the latent nature of certain insured events. See *Id.*

<sup>62</sup> “In some cases, legislators explicitly opted for a retroactive liability regime” in the area of environmental liability; “in other cases, judges held that a particular behavior (like dumping toxic waste) was already considered wrongful at the moment when the act happened (e.g., twenty-five years ago) even though it may be doubtful that this actually was the case.” See Michael G. Faure, *Insurability of Damage Caused by Climate Change: A Commentary*, 155 U. PA. L. REV. 1875, 1877–78 (2007).

emission of GHGs to the dumping of toxic waste.<sup>63</sup> Liability insurers could argue in response, however, that emitting GHGs is not like dumping toxic waste, which was affirmed in a finding of liability by judges in some cases;<sup>64</sup> it was not wrongful at the time of the act of emission and may not justify an action in tort, and thus emitting GHGs may not apply such retroactive case law.<sup>65</sup>

### B. Insurability of Climate Change Catastrophe Risk

Different from liability insurance, catastrophe insurance is a type of first-party insurance that is designed to indemnify the insured for direct losses resulting from a covered peril, the prospective victims being paid by the insurers once a covered event occurs.<sup>66</sup> Climate change risks, such as extreme weather or sea level rise, present significant challenges to catastrophe insurance due to huge losses.<sup>67</sup> Catastrophes are often called “uninsurable risks,” and insurers are likely to flee from underwriting them.<sup>68</sup> The insurance literature often identifies three factors defining an uninsurable catastrophe risk:

- (1) Ambiguity of risk, also called uncertainty: the inability to identify and quantify probabilities of predicted losses with sufficient precision;
- (2) Losses and insolvency: concern that the largest possible loss could threaten insurers’ solvency; and
- (3) Appetite: insurers lack the desire to underwrite climate change risks at a price policyholders are willing to pay.<sup>69</sup>

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<sup>63</sup> *Id.*

<sup>64</sup> See Gerrit Betlem & Michael Faure, *Environmental Toxic Torts in Europe: Some Trends in Recovery of Soil Clean-Up Costs and Damages for Personal Injury in the Netherlands, Belgium, England and Germany*, 10 GEO. INT’L ENVTL. L. REV. 855, 856–86 (1998) (noting examples and discussing retroactive case law).

<sup>65</sup> See Faure, *supra* note 62, at 1880.

<sup>66</sup> GEORGE J. COUCH, COUCH CYCLOPEDIA OF INSURANCE LAW 153 (2d ed. 1984); ROBERT H. JERRY & DOUGLAS R. RICHMOND, UNDERSTANDING INSURANCE LAW 45–46 (2012).

<sup>67</sup> For example, in 2005, Hurricane Katrina caused about \$48 billion in catastrophe-related insured losses. Howard Kunreuther & Erwann Michel-Kerjan, *Market and Government Failure in Insuring and Mitigating Natural Catastrophes: How Long-Term Contracts Can Help*, in PUBLIC INSURANCE AND PRIVATE MARKETS 115, 119–21 (Jeffery R. Brown ed., 2010); see Hecht, *supra* note 29, at 1582. After Hurricane Katrina, a lot of insurance firms cut back their coverage in coastal areas. See Hecht, *supra* note 29, at 1582; Kunreuther & Michel-Kerjan, *supra*.

<sup>68</sup> Besides huge losses caused by climate hazards, catastrophic risks require insurers to hold large amounts of liquid capital, but institutional factors (such as accounting, tax, and takeover risk) make insurers reluctant to do this. See Jaffee & Russell, *supra* note 52, at 206, 208.

<sup>69</sup> See BARUCH BERLINER, LIMITS OF INSURABILITY RISKS 42–43 (1982); Charpentier, *supra* note 14, at 91–109; Hecht, *supra* note 29, at 1565, 1580–81; Celine Herweijer et al., *Adaptation to Climate Change: Threats and Opportunities for the Insurance Industry*, 34 GENEVA PAPERS ON

This Article argues that despite these concerns, climate change catastrophe risks are, to some extent, insurable.

Climate change leads to an increase in the uncertainty associated with the frequency and severity of extreme weather events. When there is “too much” uncertainty, the exposure becomes unmeasurable and unquantifiable, and thus uninsurable. Nonetheless, with the steadily growing body of data on catastrophe events and the development of catastrophe models that could help estimate potential damages, natural catastrophe risk is evolving away from a highly uncertain line of business.<sup>70</sup>

Further, similar to liability insurance discussed above, catastrophe insurance involves concerns and arguments about the potential magnitude of catastrophe losses. To address the concern of insolvency, outside capital could supplement catastrophe insurers’ capacity to cover claims. Reinsurance and insurance-linked securitization, such as catastrophe bonds,<sup>71</sup> could provide additional capital sources to primary insurers. In addition, and as a last resort, the government could also contribute to solving this problem, because the government has a deep credit capacity due to its ability to raise money through tax or issuing government bond far more easily than private insurers or reinsurers.<sup>72</sup>

Third, the asymmetric information problem that affects insurers’ appetite may not be as severe as presumed. The so-called moral hazard might be minimal because the risk of catastrophic loss is not the private information of the insured.<sup>73</sup> In addition, many insurers cooperate with scientists on pre-

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RISK & INS. 360, 360–80 (2009), <http://www.palgrave-journals.com/gpp/journal/v34/n3/pdf/gpp200913a.pdf> [<https://perma.cc/B8JT-YWFR>]; Kunreuther & Michel-Kerjan, *supra* note 14, at 1813.

<sup>70</sup> DAVID LASTER ET AL., SWISS RE, INNOVATING TO INSURE THE UNINSURABLE 14 (2005), [http://attach3.bdwm.net/attach/boards/Insurance/M.1132324052.A/sigma\\_4\\_2005\\_e\\_rev.pdf](http://attach3.bdwm.net/attach/boards/Insurance/M.1132324052.A/sigma_4_2005_e_rev.pdf) [<https://perma.cc/X34A-BSWM>].

<sup>71</sup> Reinsurance can be understood as simply insurer’s insurance. “Insurers have traditionally protected themselves through private reinsurance contracts whereby portions of their losses from a catastrophic disaster are covered by some type of” reinsurance arrangement. Paul R. Kleindorfer & Howard C. Kunreuther, *Challenges Facing the Insurance Industry in Managing Catastrophic Risks*, in *THE FINANCING OF CATASTROPHIC RISK* 149, 151–52 (Kenneth A. Froot ed., 1999). Insurance-linked securitization could be regarded as the process of transferring insurance risks from insurers and conveying them to third parties through tradable securities. Qihao He & Ruohong Chen, *Securitization of Catastrophe Insurance Risk and Catastrophe Bonds: Experiences and Lessons to Learn*, CHINA DAILY READERS BLOG (Aug. 14, 2013), <http://blog.chinadaily.com.cn/blog-1158878-11960.html> [<https://perma.cc/8RDX-NUZZ>]. “Catastrophe bonds also called ‘cat bonds’ or ‘Act of God bonds,’ which are the most prominent and popular form of [insurance-linked securities] now.” *Id.*

<sup>72</sup> Louis Kaplow, *Incentives and Government Relief for Risk*, 4 J. RISK & UNCERTAINTY 167, 167–75 (1991).

<sup>73</sup> See Jaffee & Russell, *supra* note 52, at 206.

dicting climate change risks and thus have the advantage of information. To some extent, it helps insurers lessen moral hazard problem of the insureds.

### III. REGULATION BY LIABILITY INSURANCE FOR MITIGATION OF GHG EMISSIONS?

Although liability insurers in theory have the ability to mitigate greenhouse gas (“GHG”) emissions through regulatory tools, and though it may not be appropriate to declare climate change liability risk “uninsurable,” it is unlikely that regulation by liability insurance will function effectively in practice. Through a comparative study of the United States and China, this Part explores the possible reasons why, and identifies specific obstacles hindering regulation by liability insurance in China.<sup>74</sup>

#### *A. Tortious Liability and Liability Insurance Coverage*

The rules of tort law and the resulting liability—if any—for climate change risk play a major role in determining whether liability insurance could help mitigate GHG emissions. Any such liability would force GHG emitters to internalize the risk that insurers then regulate and manage.<sup>75</sup> If polluters face no liability for their behavior, there will be no demand for liability insurance in the first place. Thus, the current obstacles for the establishment of tortious liability need to be clearly understood.

#### 1. Obstacles to Tortious Liability

Causation uncertainty is an important issue in climate change tortious cases, as claimants must show that their damages are caused by defendants’ actions.<sup>76</sup> In climate change cases, as in many toxic tort cases, a legally sufficient causal relationship does not exist. Although the United States Supreme Court has recognized a general causal link between climate change and man-made GHG emissions,<sup>77</sup> proof of proximate causation by individual emitters is generally not available.<sup>78</sup> No decided U.S. case has found

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<sup>74</sup> See *infra* notes 75–117 and accompanying text.

<sup>75</sup> Internalizing the risk is contrary to insurance externality which refers to the situation that “if insurers do not classify insureds into sufficiently narrow risk pools, insureds will in large measure externalize accident costs to their insurers.” See Jon D. Hanson & Kyle D. Logue, *The First-Party Insurance Externality: An Economic Justification for Enterprise Liability*, 76 CORNELL L. REV. 129, 131 (1990).

<sup>76</sup> David A. Grossman, *Tort-Based Climate Litigation*, in ADJUDICATING CLIMATE CHANGE: STATE, NATIONAL AND INTERNATIONAL APPROACHES, *supra* note 51.

<sup>77</sup> *Massachusetts v. EPA*, 549 U.S. 497, 505 (2007).

<sup>78</sup> Wang, *supra* note 30, at 328.

proximate cause between the emissions of an individual emitter and adverse effects (now and in the future) on the climate.<sup>79</sup>

Causal uncertainty leads to other legal disputes that include the identification of tortfeasors and the determination of losses. Since everyone may emit some GHGs and contribute in some degree to climate change, climate change victims should determine who is a viable defendant; however, assessing the damages due to climate change and determining the number of losses is extremely hard.<sup>80</sup> For example, GHG emissions that cause damages may have happened many years ago, and this factor may hinder loss assessment.<sup>81</sup>

In response to the causal uncertainty issue, some commentators propose using proportional liability theory and market share liability theory to determine whether the emitters should be liable for damages caused by climate change; however, neither provides an adequate solution to this problem.<sup>82</sup> With respect to proportional liability, identifying the culpable emitters and the appropriate amount of damages in response to the increased risk of climate-related disasters is still unfeasible in practice.<sup>83</sup> And, in the case of market share liability, determining the accuracy and the scale of the emissions market on a global basis is quite challenging for victims.

Proof of causation is also required by several statutes in China. Article 2 of the Insurance Act requires a causal link between the risk and the loss.<sup>84</sup> A similar provision is found in Article 216(1) of the Maritime Code.<sup>85</sup> Taken

<sup>79</sup> PEEL & OSOFSKY, *supra* note 28, at 60–83.

<sup>80</sup> Ina Ebert, *Legal Aspects of US Claims Based on Greenhouse Gas Emissions*, in LIABILITY FOR CLIMATE CHANGE? EXPERTS' VIEWS ON A POTENTIAL EMERGING RISK 14, 15 (2010) [https://www.munichre.com/site/touch-publications/get/documents\\_E753942211/mr/assetpool.shared/Documents/5\\_Touch/\\_Publications/302-05493\\_en.pdf](https://www.munichre.com/site/touch-publications/get/documents_E753942211/mr/assetpool.shared/Documents/5_Touch/_Publications/302-05493_en.pdf) [<https://perma.cc/F3AX-85DW>].

<sup>81</sup> *Id.*

<sup>82</sup> The proportional liability depends on “the increased risk of natural disaster caused by GHGs.” Wang, *supra* note 30, at 328. For example, if the frequency of one extreme weather event increased by 50 percent, the emitters would be held liable for 50 percent of the victims’ losses. See Grossman, *supra* note 58, at 28–31. Market share liability was referenced in the case of *Sindell v. Abbot Laboratories*. See 607 P.2d 924, 935–37 (Cal. 1980). This approach allocates liability among market participants according to their relative shares in the national product market. See Grimm, *supra* note 13, at 211.

<sup>83</sup> Kunreuther & Michel-Kerjan, *supra* note 14, at 1835.

<sup>84</sup> Zhonghua Renmin Gongheguo Baoxianfa (中华人民共和国保险法) [Insurance Law of the P.R.C.] (promulgated by Order No. 51 of the President of the People’s Republic of China, adopted by the Standing Comm. Nat’l People’s Cong., June 30, 1995, amended by Standing Comm. Nat’l People’s Cong., Oct. 28, 2002), art. 2 (China); Article 2 of the Insurance Act provides “to indemnify the insured where property loss or damage is caused as a result of the occurrence of an insured event . . . .” INSURANCE LAW IN CHINA 100 (Johanna Hjalmarsson & Dingjing Huang eds., 2015).

<sup>85</sup> Zhonghua Renmin Gongheguo Haishangfa (中华人民共和国海商法) [Maritime Code of the P.R.C.] (promulgated by Order No. 64 of the President of the People’s Republic of China and

gether, causation uncertainty and other obstacles suggest that, under current tort rules, tortious liability might not be established between GHG emissions of individual emitters and climate change victims' losses.

## 2. Obstacles for Liability Insurance Coverage

Even if a GHG emitter's tortious liability was established by a court, obstacles would remain to insurance coverage. *AES Corp. v. Steadfast Insurance Co.*—the first and only case directly addressing climate change claims under a liability policy—shows the difficulty of prevailing on a liability insurance claim for climate change liability.<sup>86</sup>

A vital question for liability insurance coverage is whether the damage was caused by an occurrence. An “occurrence” is typically defined in U.S. liability policies as “an accident, including continuous or repeated exposure to substantially the same general harmful conditions.”<sup>87</sup> Do GHG emissions constitute an “occurrence”? The answer in *AES* is no.<sup>88</sup> The court applied the “eight corners rule” and reasoned that “when the insured knows or should have known the consequences of his actions, there is no occurrence.”<sup>89</sup> In other words, if the insured was aware of the GHG emissions, and the resulting damage was foreseeable, then there was objective intent based on the perspective of a hypothetical “reasonable” person.<sup>90</sup> The Virginia Supreme

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adopted at the 28th Meeting of the Standing Comm. Nat'l People's Cong. on Nov. 7, 1992), art. 216 (China); see also INSURANCE LAW IN CHINA, *supra* note 84, at 358.

<sup>86</sup> See 725 S.E.2d 532, 532, 534 (Va. 2012). *AES* was a defendant in the case of *Native Village of Kivalina v. ExxonMobil*. See 696 F.3d 849, 853 n.1 (9th Cir. 2012), *cert denied* 133 S.Ct. 2390 (2013). The plaintiff Kivalina sued numerous emitters of GHGs and attributed the impending destruction of its land to the defendants because of their emissions of large quantities of GHGs. See *id.* at 853–55. When sued, *AES* notified its liability insurer Steadfast Insurance Company of a duty to defend based on the provisions of their Commercial General Liability (CGL) policy. *AES Corp.*, 725 S.E.2d at 613. Steadfast stated in the Virginia Supreme Court that they did not have the duty to defend *AES* for three reasons: “(1) the Complaint did not allege ‘property damage’ caused by an ‘occurrence’ . . . ; (2) any alleged injury arose prior to the inception of Steadfast’s coverage; and (3) the claims . . . fell within the scope of the pollution exclusion . . .” *Id.* The Virginia Supreme Court applied “eight corners rule” and held that Steadfast did not have a duty to defend *AES*. See *id.* at 532, 534.

<sup>87</sup> *Virginia Supreme Court to Decide Insurance Coverage for Climate Change Suits*, MARTEN LAW (June 2, 2011), <http://www.martenlaw.com/newsletter/20110602-insurance-coverage-climate-change> [<https://perma.cc/7ZKB-VA78>].

<sup>88</sup> 725 S.E.2d at 534–35.

<sup>89</sup> The so called “eight corners rule” means the court determines whether the allegations in the underlying complaint come within the coverage provided by the policy by comparing the “four corners” of the underlying complaint with the “four corners” of the policy. See *id.*

<sup>90</sup> *Id.* at 536.

court declined to adopt the insured's subjective intent standard in assessing "occurrence."<sup>91</sup>

Chinese law presents similar rules referred to as "indirect intention." Article 27 of the Insurance Act provides: "Where the assured or the insured intentionally causes the occurrence of an insured event, the insurer is entitled to terminate the contract and shall not be liable for indemnity payment of insurance benefits."<sup>92</sup> When the insured does not intend the harm but "knows with substantial certainty that it would occur as a result of his action," that action meets the tort law requirement of "indirect intention."<sup>93</sup> Indirect intention may entitle the insurer to reject the claim since the insured's act does "intentionally" cause damage.<sup>94</sup>

There are further issues beyond those raised by *AES*. For example, the pollution exclusion is not addressed in *AES*. Whether carbon dioxide is a "pollutant" within Commercial General Liability ("CGL") policy's pollution exclusion is hotly contested,<sup>95</sup> although insureds argue that carbon dioxide is an "omnipresent," "odorless and colorless gas," and thus should not be categorized as a pollutant.<sup>96</sup> This argument was challenged in *Massachusetts v. EPA*.<sup>97</sup> The United States Supreme Court held that GHGs fell within the definition of "air pollutants" in Section 302(g) of the Clean Air Act.<sup>98</sup> The U.S. Environmental Protection Agency adheres to this judgment that GHGs are "without a doubt 'physical [and] chemical . . . substance[s] which [are] emitted into . . . the ambient air.'"<sup>99</sup>

In China, other legal doctrines impede liability insurance's potential to mitigate risk. An insurer's duty to defend is a unique example. In the United

<sup>91</sup> Steven Plitt et al., 2 COUCH ON INSURANCE § 103:27 (3d ed., 2011) (noting dispute as to whether "expected or intended" element of the term "occurrence" is "interpreted objectively or subjectively").

<sup>92</sup> Zhonghua Renmin Gongheguo Baoxianfa (中华人民共和国保险法) [Insurance Law of the P.R.C.] (promulgated by Order No. 51 of the President of the People's Republic of China, adopted by the Standing Comm. Nat'l People's Cong., June 30, 1995, amended by Standing Comm. Nat'l People's Cong., Oct. 28, 2002), art. 27 (China); see INSURANCE LAW IN CHINA, *supra* note 84, at 167.

<sup>93</sup> See INSURANCE LAW IN CHINA, *supra* note 84, at 167.

<sup>94</sup> Tao Yu, *Liability Insurance*, in INSURANCE LAW IN CHINA, *supra* note 84, at 166.

<sup>95</sup> A CGL policy normally includes a "pollution exclusion" clause. If carbon dioxide is a "pollutant," there will be no coverage for the resulting damages.

<sup>96</sup> Brief of Appellant at 19–20, *AES Corp. v. Steadfast Ins. Co.*, 715 S.E.2d 28 (Va. 2011) (No. 100764), 2010 WL 6893538, at \*19–20.

<sup>97</sup> 549 U.S. 497, 512–13, 532 (2007).

<sup>98</sup> *Id.* at 529.

<sup>99</sup> *Id.*; CLIMATE CHANGE DIV., OFFICE OF ATMOSPHERIC PROGRAMS, U.S. ENVTL. PROT. AGENCY, ENDANGERMENT AND CAUSE OR CONTRIBUTE FINDINGS FOR GREENHOUSE GASES UNDER SECTION 202(A) OF THE CLEAN AIR ACT 80 (2009) (quoting *Virginia Supreme Court to Decide Insurance Coverage for Climate Change Suits*, *supra* note 87.).

States, the duty to defend, an essential part of a liability insurance policy, means that the insurers agree not only to pay tort judgments against the policyholder but also to defend the lawsuits brought by plaintiffs against the policyholder even if the suit is groundless, false, or fraudulent.<sup>100</sup> Due to the duty to defend, liability insurers in the United States might be forced to become involved in climate change litigations.<sup>101</sup> In China, however, insurance law only specifies the liability insurers' duty to indemnify but "imposes no duty to defend the insureds."<sup>102</sup> Although insurers have the right to participate in an action against the plaintiffs, in practice few insurers participate in the tortious litigation or the settlement.<sup>103</sup> Since insurers aren't bound by a duty to defend, when claimants sue GHG emitters, liability insurers have fewer incentives to become involved in such tortious liability cases, let alone in regulating emitters' behaviors. In other words, they have few incentives to regulate emitters' behaviors because it's less costly for them if the insureds produce more emissions and then if they are sued as a result.

### *B. Environmental Liability Insurance in China: Obstacles and Lessons*

The prospects are not rosy for mitigating GHG emissions in China through liability insurance. Because climate change liability risk is a kind of environmental risk, environmental liability insurance in China is worth analyzing for possible lessons and obstacles. The number of environmental tort liability cases is rapidly increasing in China.<sup>104</sup> Meanwhile, environmental-risk insurance products are becoming increasingly available and strongly promoted by the Chinese government.<sup>105</sup> Even if climate change risk was covered under existing environmental policies, however, it is unlikely that such insurance could provide significant incentives for reduction of GHG emissions. The reasons are as follows.

First, the penetration rate of environmental liability insurance is low. A glance at the environmental insurance market in China reveals three major insurance products covering environmental risks.<sup>106</sup> The first product is a general liability insurance policy that was extended three or four years ago to

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<sup>100</sup> Stempel, *supra* note 51, at 235.

<sup>101</sup> *Id.*

<sup>102</sup> Yu, *supra* note 94, at 161.

<sup>103</sup> *Id.* at 169.

<sup>104</sup> Daniel Carpenter-Gold, Note, *Castles Made of Sand: Public-Interest Litigation and China's New Environmental Protection Law*, 39 HARV. ENVTL. L. REV. 241, 242 (2015).

<sup>105</sup> Michael G. Faure & Liu Jing, *Compensation for Environmental Damage in China: Theory and Practice*, 31 PACE ENVTL. L. REV. 226, 228 (2014).

<sup>106</sup> See *infra* notes 107–109 and accompanying text.

cover several kinds of pollution risks.<sup>107</sup> A second is environmental liability insurance that mainly covers personal injuries and property damage caused by pollution; Chinese insurers started offering this stand-alone policy after 2007.<sup>108</sup> A third option involves pollution-site liability that provides coverage for damage to third parties as well as remediation costs for polluted sites.<sup>109</sup> Since 2007, eight provinces and cities—Jiangsu, Hubei, Hunan, Henan, Chongqing, Shenzhen, Ningbo, and Shenyang—have been chosen to develop and promote liability insurance to cover various dangerous industrial risks, such as dangerous chemicals, waste treatment, and petrochemicals.<sup>110</sup> The revenue from environmental liability insurance only accounted for 0.015 percent of the total liability insurance revenue in these experimental areas in 2009.<sup>111</sup>

Second, coverage obstacles still exist under environmental liability insurance policies, which cover pollution. *Pollution* is not clearly defined in the general environmental liability insurance policy.<sup>112</sup> Whether GHGs belong among pollutants remains an uncertainty. To avoid potential risk, the insurers may modify the policy language to exclude liability arising from climate change claims against policyholders. Further, the causal uncertainty associated with climate-change-related claims makes it difficult to bring a claim. Finally, the third-party victims still need to prove a causal link between their losses and the insureds' emissions.

As a result of the above debates related to tortious liability rules, liability insurance coverage, and the environmental policies market in China, liability insurance would not be viable and may not be efficient in encouraging the mitigation of current GHG emissions. Government regulation might be the more efficient approach. China's approach to addressing GHG emissions "relies heavily on top-down, command-and-control regulation, built around bureaucratic targets and controls for local officials and state-owned enterprise leaders."<sup>113</sup> Most recently, the Chinese central gov-

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<sup>107</sup> Faure & Jing, *supra* note 105, at 269.

<sup>108</sup> *Id.* at 269–70.

<sup>109</sup> *Id.* at 271.

<sup>110</sup> See Yan Feng et al., *Environmental Pollution Liability Insurance in China: In Need of Strong Government Backing*, 43 *AMBIO* 687, 692 (2013); Lijing Liang & Jialin, *The Ministry of Environmental Protection Tries to Promote Compulsory Environmental Liability Insurance*, SINA (July 9, 2012), <http://green.sina.com.cn/2012-07-09/103024739500.shtml> [<https://perma.cc/5XK7-FBUF>].

<sup>111</sup> Yan Feng et al., *supra* note 103, at 696; Liang & Jialin, *supra* note 103.

<sup>112</sup> Faure & Jing, *supra* note 105, at 268–69.

<sup>113</sup> Wang, *supra* note 8, at 2. Illustrations of top-down, command-and-control regulations include but are not limited to the following: central authorities have been given great authority to punish bureaucrats and state-owned enterprise leaders for failing to meet energy, carbon, and pollution targets; central authorities issued detailed implementation rules and offered trainings to assist local government actors in implementation; and central regulators developed multiple data

ernment has made an international commitment to “lower carbon dioxide emissions per unit of GDP to 60% to 65% from the 2005 level by 2030” and to start its national emissions trading system in 2017.<sup>114</sup>

In the future, the government could also establish a climate change compensation fund and require major emitters to bear the responsibility for premiums.<sup>115</sup> The no-fault compensation mechanism of the climate change fund could provide basic compensation for victims and might adopt the polluter-pays principle to encourage emitters to internalize the external cost of GHGs.<sup>116</sup> This scheme might be more viable than a tort-based liability insurance model because it could avoid the obstacles to tortious liability and liability insurance coverage.<sup>117</sup> Because regulation by liability insurance in mitigation of GHG emissions is not viable in China, the following Part discusses regulation by catastrophe insurance and explores how to mitigate the value-at-risk.<sup>118</sup>

#### IV. REGULATION BY CATASTROPHE INSURANCE FOR MITIGATION OF VALUE-AT-RISK

While third-party liability insurance might be infeasible for mitigating climate change risks, catastrophe insurance has drawn attention as a means of mitigating climate change risks—mainly value-at-risk—both in theoretical discussion and in practice.<sup>119</sup> In China, catastrophe insurance does have the potential to regulate insureds’ behavior so as to mitigate risks.

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sources and more readily observable proxies for target implementation. Alex L. Wang, *The Search for Sustainable Legitimacy: Environmental Law and Bureaucracy in China*, 37 HARV. ENVTL. L. REV. 365, 379–85 (2013).

<sup>114</sup> Press Release, White House Office of the Press Sec’y, U.S.-China Joint Presidential Statement on Climate Change (Sept. 25, 2015), <https://www.whitehouse.gov/the-press-office/2015/09/25/us-china-joint-presidential-statement-climate-change> [<https://perma.cc/PW5R-EXAF>].

<sup>115</sup> Melissa Farris, *Compensation Climate Change Victims: The Climate Compensation Fund as an Alternative to Tort Litigation*, 2 SEA GRANT L. & POL’Y J. 49, 60 (2009–2010).

<sup>116</sup> *Id.*

<sup>117</sup> Of course, the discussion of applying administrative power to mitigate GHG emissions is beyond the scope of this Article.

<sup>118</sup> See *infra* notes 119–151 and accompanying text.

<sup>119</sup> For example, most government-sponsored catastrophe insurance programs are first-party insurance, such as the National Flood Insurance Program in the United States. See U.S. GOV’T ACCOUNTABILITY OFFICE, GAO-08-28, NATIONAL FLOOD INSURANCE PROGRAM: GREATER TRANSPARENCY AND OVERSIGHT OF WIND AND FLOOD DAMAGE DETERMINATIONS ARE NEEDED 6–8 (2007), <http://www.gao.gov/assets/280/270814.pdf> [<https://perma.cc/H95G-PVQA>]. Some scholars discuss how to address catastrophic risks and emphasize the role of first-party insurance. See Michael Faure & Véronique Bruggeman, *Catastrophic Risks and First-Party Insurance*, 15 CONN. INS. L.J. 1, 2 (2008).

### A. *The Liability Insurance Versus Catastrophe Insurance Models*

Insurance is regarded as a powerful regulatory mechanism in many fields of liability, including automobile accidents, workplace injuries, environmental harms, corporate and securities liability, medical malpractice, defective products, and defamation.<sup>120</sup> In the traditional framework, liability insurance can incentivize potential tortfeasors to internalize the costs of the harms they create through its capacity to manage moral hazard and other bad acts of the insureds.<sup>121</sup> Thus, it improves the efficiency of risk mitigation. When it comes to climate change risks, as discussed above, however, regulation by liability insurance to mitigate risks faces theoretical and practical obstacles.<sup>122</sup>

In contrast with liability insurance that focuses on greenhouse gas (“GHG”) emitters, catastrophe insurance, mainly focusing on victims of climate hazards, can conquer causal uncertainty and other tort liability obstacles. With respect to causal uncertainty, the major barrier from tort doctrines would disappear because climate change victims could seek compensation from catastrophe insurers directly without having to establish the liability of the emitters.<sup>123</sup> Catastrophe insurance shifts the causal connection between the emitters’ activities and the losses of the victims.

The catastrophe insurer has several regulatory techniques to minimize value-at-risk and protect insureds from climate hazards, among them risk-based pricing, contract design, loss prevention services, and claim management.<sup>124</sup> Risk-based pricing is the most basic technique for creating incentives to reduce risk.<sup>125</sup> Risk-based premiums enable insurers to provide a discount to insureds adopting cost-effective mitigation measures and thus also provide a clear signal to other insureds in the market.<sup>126</sup> By including such elements as deductibles, copayments, coverage amount limit, and exclusions, contract design can also be used to regulate risk both directly and

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<sup>120</sup> Baker & Swedloff, *supra* note 40, at 1423–38; see Tom Baker, *Liability Insurance as Tort Regulation: Six Ways That Liability Insurance Shapes Tort Law in Action*, 12 CONN. INS. L.J. 1, 3–13 (2005).

<sup>121</sup> Ben-Shahar & Logue, *supra* note 39, at 210–12.

<sup>122</sup> See *supra* notes 76–117 and accompanying discussion.

<sup>123</sup> Wang, *supra* note 30, at 331.

<sup>124</sup> These regulatory tools are widely discussed in a series of articles written by regulation-by-insurance scholars. See, e.g., Baker & Swedloff, *supra* note 40, at 1416–23; Ben-Shahar & Logue, *supra* note 39, at 205–15; Surminski, *supra* note 44, at 264–69; Shauhin A. Talesh, *Legal Intermediaries: How Insurance Companies Construct the Meaning of Compliance with Anti-Discrimination Laws*, 37 L. & POL’Y 209, 216–18 (2015).

<sup>125</sup> Ben-Shahar & Logue, *supra* note 39, at 205–08.

<sup>126</sup> Howard Kunreuther, *Reducing Losses from Catastrophe Risks Through Long-Term Insurance and Mitigation*, 75 SOCIAL RES. 905, 916 (2008).

indirectly. The deductible is an example. It can mitigate moral hazard directly because it prevents victims of climate hazards from shielding themselves entirely from loss and thus encourages them to exercise greater vigilance than would be the case without deductibles.<sup>127</sup>

Furthermore, catastrophe insurers could provide loss-prevention services such as flood-proofing of buildings or retrofitting of houses against windstorms.<sup>128</sup> With respect to climate change risks, to some extent, insurers have an advantage because catastrophe insurers have worked in tandem with scientists to identify technical and economic parameters of climate change risks and to develop system-wide technologies for loss prevention.<sup>129</sup> Claim management is necessary to control *ex post* moral hazard of insureds as a result of their inability to change the possibility of a climate hazard despite their ability to mitigate disaster losses.<sup>130</sup> Catastrophe insurers also employ adjusters “to investigate claimed losses, measure them, and negotiate payouts” to provide greater uniformity and predictability.<sup>131</sup>

In terms of the catastrophe insurance model, drawbacks may also exist along with the above merits. First, because of the highly correlated nature and potential concentration of losses from extreme weather exposures, insurers’ capacity and appetite to cover such losses may not be sufficient.<sup>132</sup> For this reason, at least in U.S. Gulf Coast states, standard homeowners’ insurance policies typically exclude losses from floods and also for wind.<sup>133</sup> Even endorsements that add coverage for these events at additional expense are normally unavailable.<sup>134</sup> The second drawback is that potential victims may fail to purchase insurance against low-probability extreme weather disasters because of the observed behavioral anomaly of individuals to underestimate the expected costs of extreme weather hazards and also because of repeated government bailouts.<sup>135</sup> Accordingly, these drawbacks associ-

<sup>127</sup> Baker & Swedloff, *supra* note 40, at 1420–21.

<sup>128</sup> Surminski, *supra* note 44, at 241, 264.

<sup>129</sup> Peter Stott et al., *Human Contribution to the European Heat Wave of 2003*, 432 NATURE 610, 610–14 (2004).

<sup>130</sup> This is workable because policyholder’s generally lack concern over the cost of a claim once it occurs. See Baker & Swedloff, *supra* note 40, at 1421.

<sup>131</sup> Ben-Shahar & Logue, *supra* note 39, at 213.

<sup>132</sup> Howard Kunreuther, *The Role of Insurance in Reducing Losses from Extreme Events: The Need for Public-Private Partnerships*, 40 GENEVA PAPERS ON RISK & INS. 741, 754 (2015).

<sup>133</sup> Molk, *supra* note 41, at 265–77.

<sup>134</sup> *Id.* Endorsements are clauses in an insurance policy detailing an exemption from or change in coverage. When an endorsement modifies, qualifies, or restricts the terms of the original policy, the endorsement controls. See Plitt et al., *supra* note 91, at § 21:22.

<sup>135</sup> HOWARD KUNREUTHER ET AL., INSURANCE AND BEHAVIORAL ECONOMICS: IMPROVING DECISIONS IN THE MOST MISUNDERSTOOD INDUSTRY 114–15 (2013).

ated with catastrophe insurance would need to be addressed to develop a feasible catastrophe insurance model.

*B. Developing a Feasible Catastrophe Insurance-Based Private-Public Partnership for China*

Catastrophe risks have never been covered systematically by either private insurance or government insurance in China. For example, only 0.3 percent of total losses were covered by insurance companies in the 2008 Great Wenchuan Earthquake.<sup>136</sup> It was only in 2014 that the central government established the catastrophe insurance program trials in the cities of Shenzhen and Ningbo and the region of Chuxiong where the catastrophe risk would be “shared between the government, insurance and reinsurance firms and individuals.”<sup>137</sup> In considering the current insurance market in China, a phased catastrophe insurance-based private-public partnership that marries the merits of both insurance and government in mitigation of value-at-risk might address the problems described above. The nuts and bolts of this partnership are as follows.

First, under such a partnership, the state would require all property insurers to provide catastrophe coverage for residential properties. In doing so, it would be important for the government to avoid interfering with private insurers’ actuarially fair pricing. Insurance premiums reflecting risks can provide individuals with accurate signals in cost-effective mitigation measures.<sup>138</sup> This could be difficult because the Chinese government could face political pressure to interfere with insurers’ risk classification and risk-based premiums, particularly because risk classification is not always compatible with social solidarity objectives in China that promote equal treatment of all citizens.<sup>139</sup> Nevertheless, even if there are concerns about the affordability of catastrophe insurance, it is better for the government to provide subsidies to lower-income residents, such as through insurance vouchers, than to suppress insurers’ incentives to underwrite policies and distort risk signals provided by actuarially-based premiums. Therefore, the gov-

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<sup>136</sup> *Establishing Catastrophe Insurance System Faces Acceleration*, CHINA YOUTH DAILY, (Mar. 14, 2011), [http://zqb.cyol.com/html/2011-03/14/nw.D110000zgqnb\\_20110314\\_1-05.htm?div=-1](http://zqb.cyol.com/html/2011-03/14/nw.D110000zgqnb_20110314_1-05.htm?div=-1) [<https://perma.cc/XGM8-MXAU>].

<sup>137</sup> *China Says Testing Catastrophe Insurance System*, BUS. INS. (Aug. 20, 2014), <http://www.businessinsurance.com/article/20140820/NEWS04/140829990?AllowView=VDI3UXk1T3hDUFNCbkJiYkY1TDJaRUt0ajBRV0ErOVVHUT09#> [<https://perma.cc/JD57-FJFY>].

<sup>138</sup> Kunreuther, *supra* note 132, at 750–51.

<sup>139</sup> J. DAVID CUMMINS & OLIVIER MAHUL, WORLD BANK, CATASTROPHE RISK FINANCING IN DEVELOPING COUNTRIES: PRINCIPLES FOR PUBLIC INTERVENTION 76–78 (2009), <http://site.resources.worldbank.org/FINANCIALSECTOR/Resources/CATRISKbook.pdf> [<https://perma.cc/Y2PA-H34P>].

ernment should neither create new institutions to supplant private solutions nor suppress premiums of insurance policies. As a Chinese proverb says, “You can’t expect the horse to run fast when you don’t let it graze.” The state cannot expect the insurers to underwrite policyholders’ risks if it does not let insurers make profits. Furthermore, that type of rate regulation would undermine this insurance’s effectiveness as a risk mitigation device.

Second, recognizing private insurers’ reluctance to underwrite catastrophe risks without any meaningful underwriting history, predictive model, or sufficient capacity, the state could provide a government-funded backstop that assumes the risks of any losses above a predetermined threshold, thereby capping private insurers’ maximum exposure. This type of cap could promote the initial entry of private insurers.<sup>140</sup>

Third, after several years, maybe longer, when private insurers have gained underwriting experience and developed models, this type of government support could be removed. This, however, may be easier said than done. In this respect, the U.S. terrorism coverage program, Terrorism Risk Insurance Act (“TRIA”), provides a cautionary lesson.<sup>141</sup> Established after the terrorist attacks of September 11, 2001, TRIA has been twice extended for a total of nine years past its original 2005 horizon.<sup>142</sup> This is a good example of why government support is difficult to phase out over time. One possible reason lies that insurers lobby to keep it in place.

Fourth, the state can use its powers of compulsion to bring more residents into the pool, which maximizes risk spreading, in turn maximizing consumer participation in the insurance market and minimizing adverse selection worries. Compulsory insurance is practiced in some countries, such as in the case of the Caisse Centrale de Réassurance (CCR) program in France<sup>143</sup> and the Turkish Catastrophe Insurance Pool (TCIP).<sup>144</sup> An insur-

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<sup>140</sup> For example, following Hurricane Andrew, the Florida Hurricane Catastrophe Fund, established to reimburse all insurers for a portion of their losses from catastrophic hurricanes, has proven that a government reinsurance facility can assist catastrophe coverage when insurers are inclined to withdraw from the catastrophe insurance market. See Kunreuther, *supra* note 132, at 749–50.

<sup>141</sup> See Terrorism Risk Insurance Act, Pub. L. 107-297, 116 Stat. 2322 (codified as amended at scattered sections of 12, 15, and 28 of the U.S.C.)

<sup>142</sup> TRIA, which is facing yet an additional extension of six more years, shows the practical difficulties in committing to a “temporary” subsidy. See Molk, *supra* note 41, at 265–77.

<sup>143</sup> The CCR, as a mandatory comprehensive disaster insurance model, has existed in France since 1987, has also been recently introduced in Belgium, and is under consideration in other countries. See Giuseppe Dari-Mattiacci & Michael G. Faure, *The Economics of Disaster Relief*, 37 L. & POL’Y 180, 183 (2015).

<sup>144</sup> The TCIP is regarded as one of the best practices of private-public partnerships in an emerging market designed to reduce economic losses from disasters. See B. Burcak Başbuğ-Erkan & Ozlem Yilmaz, *Successes and Failures of Compulsory Risk Mitigation: Re-Evaluating the Turkish Catastrophe Insurance Pool*, 39 DISASTERS 782, 782 (2015).

ance mandate is particularly important in China, given its recent history of a planned economy.<sup>145</sup> The Chinese people still have a strong reliance on government, especially in the aftermath of a catastrophe. Under the Whole-Nation System,<sup>146</sup> the government is committed to bailing victims out after a disaster. According to an empirical study on property and casualty insurance in five Chinese provinces, there is a negative correlation between the amount of government relief and residents' investment in prevention measures such as purchasing insurance.<sup>147</sup> Without a compulsory requirement, residents in China will seldom purchase insurance to transfer casualty risks.

Fifth, the state should give special treatment to low-income individuals currently residing in hazard-prone areas because of equity and affordability issues.<sup>148</sup> For example, the state could provide means-tested vouchers that are a way to maintain risk-based premiums while covering part of the cost of insurance.<sup>149</sup> As a condition for the voucher, the government could then require property owners to invest in mitigation based on their affordability.<sup>150</sup>

Sixth, besides intervention into the insurance market, the state could adopt administrative measures or regulations to require residents to take mitigation measures. Such measures or regulations should coordinate with risk-based insurance premiums. For example, the state could update its building code standards and enforce high-wind design provisions for residential housing.<sup>151</sup>

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<sup>145</sup> Under the planned economic system, private insurance markets are shut down because there is no need for business insurance, as the government would bear all risks and cover individuals' exposures.

<sup>146</sup> "Whole-Nation System" (*Juguo tizhi*) . . . generally refers to the government's effort to deploy and allocate the whole nation's resources to fulfill a specific difficult task within limited time and thus promote the nation's interest." Qihao He, *Climate Change, Catastrophe Risk and Government Responsibilities* 4 (2015) (unpublished manuscript), [http://works.bepress.com/qihao\\_he/1/](http://works.bepress.com/qihao_he/1/) [<https://perma.cc/Z4DC-B6UK>]; see Peijun Shi & Xin Zhang, *Chinese Mechanism against Catastrophe Risk—the Experience of Great Sichuan Earthquake*, 28 J. TSINGHUA U. 96, 111 (2013).

<sup>147</sup> Ling Tian & Yue Zhang, *Influence Factors of Catastrophe Insurance Demand in China—Panel Analysis in a Case of Insurance Premium Income of Five Provinces*, 26 J. WUHAN U. TECH. 175, 175–79 (2013).

<sup>148</sup> Howard Kunreuther, *Reducing Losses from Catastrophes: Role of Insurance and Other Policy Tools*, ENV'T: SCI. & POL'Y FOR SUSTAINABLE DEV. (Jan.-Feb. 2016), [http://www.environmentmagazine.org/Archives/Back%20Issues/2016/January-February%202016/retrospective\\_full.html](http://www.environmentmagazine.org/Archives/Back%20Issues/2016/January-February%202016/retrospective_full.html) [<https://perma.cc/QS2H-DRTA>]. Under a compulsory insurance program, low-income individuals would be required to have insurance even if they could not afford it.

<sup>149</sup> Kunreuther, *supra* note 132, at 753–54.

<sup>150</sup> Howard Kunreuther, *Reducing Losses from Extreme Events*, INSURANCETHOUGHTLEADERSHIP.COM (Aug. 11, 2015), <http://insurancethoughtleadership.com/reducing-losses-from-extreme-events/> [<https://perma.cc/FU66-T849>].

<sup>151</sup> *Id.*

## CONCLUSION

In the context of climate change risk management, either private insurance or the state can play a crucial role in mitigating risks. As the preceding discussion of liability insurance and catastrophe insurance makes clear, catastrophe insurance is a much more feasible method of regulating climate change risks. In addition, to take advantage of the state's compulsory power, this Article proposes a feasible solution marrying the merits of both state and private insurance. Compulsory catastrophe-insurance-based private-public partnership will not only enhance mitigation of value-at-risk but also provide the victims with sufficient financial protections for climate hazards that are not eliminated. This hybrid mechanism has become a prototype for developing catastrophe insurance in several countries. It should be developed as soon as possible in China to cope with the increasing risks of climate change.

