Reputation Collectives: How International Industry Associations Influence China's Safety Standards in High-Risk Technologies*

Jeffrey Ding and Dennis Li+

August 2024

Abstract

Emerging economies face significant challenges in managing safety risks from powerful technological systems. Indeed, many analysts have identified China as the most likely source of a major accident linked to emerging technologies. Yet, contrary to these expectations, China has achieved a remarkable safety record in certain technological domains, such as civil aviation and nuclear power. How? We theorize that, for industries in which one firm's accident damages the reputation of all others, international industry associations can contribute to improved safety standards in emerging economies. When firms share a collective reputation, industry associations exert positive peer pressure by subsidizing laggards' efforts to raise their safety standards and protecting members from public naming and shaming. This departs from existing theories of international private regulation on certification clubs that set strict quality, safety, and environmental standards to deny association benefits to non-members. To demonstrate differences between these two mechanisms, we examine interactions between international industry associations and Chinese firms in three high-risk technological domains: nuclear power, civil aviation, and chemicals. Our findings have implications for scholars interested in the interdependencies between international public regulation and private regulation as well as policymakers trying to manage the safety risks of emerging technologies such as artificial intelligence.

* For helpful feedback, we thank Erik Lin-Greenberg, Eleanor Albert, Nick Anderson, Aaron Bateman, Erica De Bruin, Alex Downes, Alex Lennon, Jon Lindsay, Rachel Metz, Rebecca Slayton, Joanna Spear, Hannah Sworn, Robert Trager, Lee Vinsel, Josephine Wolff, Jackie Wong, participants at George Washington University's Institute for Security and Conflict Studies workshop, and especially Aseem Prakash.

+ Jeffrey is an Assistant Professor of Political Science, George Washington University. Correspondence email: jeffreyding@gwu.edu. Dennis is a PhD Candidate in political science at George Washington University.

I. Introduction

Technological advances promise to improve the world, but they may also sow the seeds of its destruction. Following Charles Perrow's seminal text *Normal Accidents*, social scientists have warned that highly complex, tightly coupled technological systems will inevitably fail due to unpredictable interactions that cascade, making them catastrophes waiting to happen.[1] The worst nuclear disaster of the Cold War was not caused by deliberate escalation of the nuclear arms race, miscalculation, or a rogue commander launching a nuclear strike without authorization; rather, it was precipitated by an accident at the Chernobyl nuclear power station, which released more than 400 times as much radioactive material as the U.S. nuclear bomb dropped on Hiroshima.[2]

In recent years, China's approach to managing technological accidents has drawn increasing scrutiny. With China's rapid economic and technological advances, the international community has paid more attention to its governance of safety risks in aviation, coal mines, nuclear power plants, and other sectors.[3] Existing literature expects technological accident risks to be particularly high in China due to the tendency of authoritarian regimes to suppress information and limit transparency, as well as low levels of regulatory quality and independence.[4] Based on figures from the Emergency Events Database, maintained by the Center for Research on the Epidemiology of Disasters, one study identified China as "one of the most accident-prone countries in the world."[5]

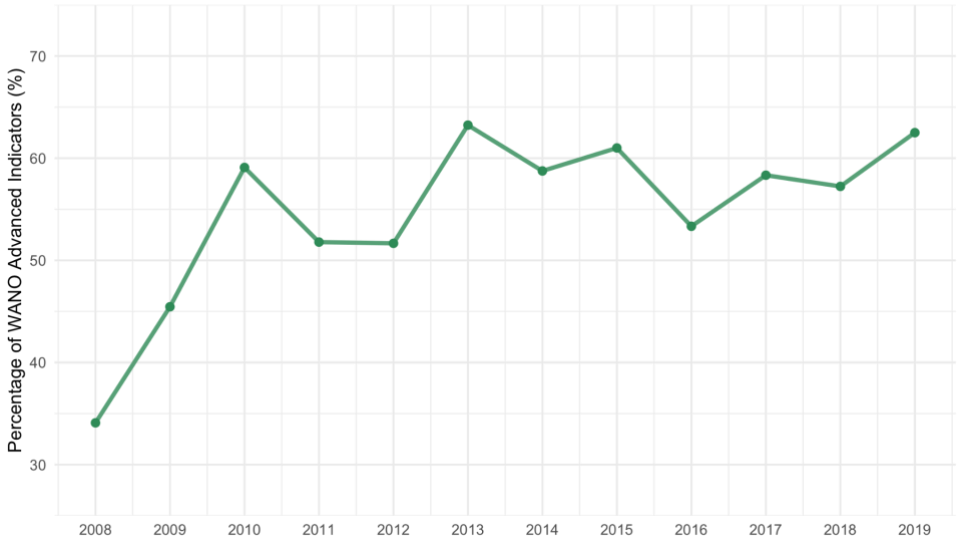
Moreover, some analysts see China as the most likely source of accidents in emerging technologies like artificial intelligence (AI). As states attempt to proactively prevent powerful AI systems from escaping human control — reflected by the Bletchley Declaration signed by 28 countries at the world's first AI safety summit in November 2023 — one question looms large: What about China? In a *Foreign Affairs* essay, two researchers at the Center for a New American Security argue, "Due to Beijing's lax approach toward technological hazards and its chronic mismanagement of crises, the danger of AI accidents is most severe in China."[6]

Yet, contrary to these expectations, China has achieved a remarkable safety record in certain technological domains, such as civil aviation, space launches, and nuclear power.[7] China's aviation safety record leads the world by some metrics, and the U.S. Federal Aviation Administration even sought to use the Chinese model to help India improve its aviation safety.[8] Likewise, China has registered impressive nuclear safety improvements. One useful benchmark is the system of safety indicators managed by the World Association of Nuclear Operators (WANO), an international

[1] Perrow 1984.
[2] IAEA 1997.
[3] Suttmeier 2008.
[4] Based on the Worldwide Governance Indicators, China ranks around 40th percentile in regulatory quality, and this figure declined from 2011 to 2021.
[5] McLean and Whang 2020.
[6] Drexel and Kelley 2023.
[7] On "the virtually failure-free PRC launch record," see Erickson 2014.
[8] Pasztor 2007.

organization that helps nuclear operators achieve higher levels of safety and reliability. Since 2008, the percentage of safety indicators in China's nuclear power plants that exceed the WANO Advanced standard (75th percentile) has nearly doubled (Figure 1).[9] How has China exceeded expectations in these domains?

Figure 1: Nuclear Safety Performance in China (2008 Reference)



Source: China Nuclear Energy Yearbook 2009-2020.

In this article, we develop a theory of how international industry associations like WANO can contribute to improved technological safety in emerging economies. For industries with a collective safety reputation, such that an accident in one firm damages the image of all others, firms are driven to organize global industry associations dedicated to improve industry-wide safety performance. To achieve this goal, these organizations (which we call "reputation collectives") institutionalize safety indicators that allow firms to compare their performance against others, sharing of best practices, and peer reviews of safety operations. In short, they exert positive peer pressure. While global private governance is often unreliable, we argue that reputation collectives can play a valuable role in raising safety standards in emerging economies, in contexts with weak domestic and international public regulators.

Crucially, this process differs from existing theories of international private regulation, which centers on certification clubs that establish strict quality, safety, or environmental standards and deny membership benefits to firms that fall short of those standards. In contrast, under our "reputation collective" mechanism, international industry associations endeavor to admit all firms as members, as the weakest safety performers threaten the reputation of all. Specifically, we theorize that

[9] Figure 1 uses WANO 2008 benchmarks to ensure temporal consistency in illustrating variation over time. It is important to note that both WANO Advanced and WANO Median values are refreshed annually and have gradually become stricter. As a result, China's safety performance appears less impressive when floating standards are applied (see Appendix Figure A1). Nevertheless, most Chinese units still remained above the WANO Median under these floating standards.

reputation collectives differ from certification clubs by treating industry reputation as a communal and non-exclusive good, safeguarding information shared among members from external stakeholders, and subsidizing weak links to keep them integrated in the group.

To demonstrate differences between the certification club and reputation collective mechanisms, we examine interactions between international industry associations and Chinese firms in three high-risk technological domains: nuclear power (1987-2020), civil aviation (1990-2008), and chemicals (2002-2021). In all three sectors, background conditions suggest that an international industry association positively influenced China's safety advances, which means they are fertile ground for differentiating between the particular mechanisms at work. Taking the form of expert interviews, Chinese-language resources, and new data, evidence from these cases substantiate the validity of the reputation collective mechanism in high-risk industries with shared safety reputations.

This article makes three main contributions. First, it presents a novel explanation for how international organizations can help govern high-risk technologies in emerging economies. Some existing scholarship argues that as states become more economically developed, an enlarged middle class pushes for institutions that foster stronger regulatory regimes on industrial safety, such as democratic political institutions and autonomous labor associations.[10] Other work highlights public international regulation by way of intergovernmental organizations and transgovernmental networks. In the case of China's improved aviation safety record, scholars have found that binding international agreements, such as the Convention on International Civil Aviation, helped Chinese regulators assert more authority.[11] This article demonstrates that international industry associations can be effective transmission belts for elevating safety standards, even in countries without the domestic institutions traditionally associated with protecting against technological accidents and contexts where international agreements are weakly enforced.

Second, this article also contributes to the growing body of scholarship on international private regulation as an essential part of the global governance toolkit, especially in settings with limited international legal instruments and countries with underdeveloped regulatory systems.[12] Much of this literature has focused on analyzing the effectiveness of international certification standards at raising quality control, environmental, and safety standards in various domains.[13] While certification clubs illuminate how global governance operates through private organizations in many sectors, this article demonstrates that, in certain industries bound to a shared reputation, the reputation collectives mechanism serves as a more appropriate explanation for how international private regulation raises safety standards in emerging economies.

Third, this article's findings also bear on discussions about intensifying competition between major powers in emerging technologies. In the AI domain, concerns over an "arms race" between

[10] Suttmeier 2008.
[11] Yasuda 2021.
[12] Abbott and Snidal 2013; Prakash and Potoski 2006.
[13] Potoski and Prakash 2006; Prakash and Potoski 2006.

the U.S. and China dominate the policymaking and scholarly discourse.[14] Paul Scharre, who previously led the U.S. Department of Defense's work on autonomy in weapon systems, writes, "For each country, the real danger is not that it will fall behind its competitors in AI but that the perception of a race will prompt everyone to rush to deploy unsafe AI systems."[15] Some researchers posit that, in the competition over emerging technologies, challengers such as China might be more willing to initiate "a race to the bottom on safety."[16] This article intervenes in these debates. Claims that China will underinvest in technological safety rarely draw on rigorous, systematic analysis. Improved understanding of how international industry associations influenced China's safety improvements in other high-risk technologies could shed light on how it will govern powerful AI systems in the future, especially since industry actors lead development in many emerging technologies.

II. Theory

How can developing countries and emerging economies achieve higher safety standards in hazardous technologies? There are two sets of standard explanations. First, domestic politics play a clear role. Democratic political institutions foster decentralized mechanisms for risk management that hold the state accountable for accidents, such as independent regulatory authorities. Under the modernization mechanism, as a state gets wealthier, an expanded middle class compels the government to address safety risks by establishing stronger regulatory regimes. This process is captured by the slogan: "first rich, then green and safe."[17]

Another literature base, centered on regulatory development in authoritarian regimes, calls attention to the influence of international actors on elevating safety standards in emerging economies, even those with limited regulatory independence and democratic accountability. According to this body of scholarship, some regulators in authoritarian states exploit pressure from international organizations to push reforms past domestic political opposition.[18] In accounts of China's impressive turnaround in civil aviation safety, the International Civil Aviation Organization, a specialized UN agency, provides this leverage — in the form of binding international standards — for Chinese regulators to push through stringent reforms.[19]

Puzzlingly, in some contexts in which these two factors are absent, states have still been able to achieve gains in technological safety. In civil nuclear power, for instance, China has achieved a

[14] Zwetsloot, Toner, and Ding 2018.
[15] Scharre 2019.
[16] Drexel and Kelley 2023.
[17] For a review of this literature, see Suttmeier 2008.
[18] Eichengreen and Xia 2019; Yasuda 2021.
[19] As Yasuda writes, "CAAC officials met frequently with their ICAO and FAA counterparts, working in concert with them to force recalcitrant airline officials to bend to their demands." Yasuda 2021, 133. See also Andrews-Speed 2020. On adverse publicity outside China as a driving factor for China devoting more resources to coal mine safety, see Wright 2022.

stronger safety record without an independent regulator or a strong international regulatory regime.[20] Nuclear safety reviews conducted by the IAEA are voluntary, and the recommendations that come out of these reviews are non-binding. As the Belfer Center's Matthew Bunn and Olli Heinonen state, "These institutions still leave primarily to each country the decisions about what nuclear safety and security measures to take, with only broad and largely voluntary international standards in place and weak authority for global institutions like the IAEA."[21]

In this article, we theorize that international industry associations present another mechanism by which emerging market countries can reduce the risks of hazardous technologies, even without robust democratic institutions and strong intergovernmental regulators. The basis of our argument is that, for industries in which firms share a collective reputation, associations of firms exert positive peer pressure. As company leaders become socialized in groups that seek to govern such high-risk domains, their beliefs converge with their global counterparts on safety issues.[22] International industry associations institutionalize these social pressures in a variety of ways, including: exchanges of best practices and lessons learned, performance indicators that incentivize members to benchmark their safety performance against their competitors, and peer review activities in which members assess each other's safety measures.

Departing from the focus on *public* international regulation through intergovernmental organizations and transgovernmental networks, our argument builds on a growing body of literature that highlights the significance of international *private* regulation.[23] To be sure, industry self-regulation can often be ineffective, fragmented, and substitute public relations window-dressing for genuine betterment.[24] However, studies of international private regimes have found that they can play a valuable regulatory role in some settings, such as when backed by the threat of public regulations and in developing countries that lack capacity for traditional regulation.[25]

One important thread of scholarship has shown that international certification standards have helped improve environmental, quality control, and safety standards across various industries such as apparel, coffee, and food.[26] These transnational private regulations work under a "certification club" model. Using language that differentiates club goods from other types of goods, Matthew Potoski and Aseem Prakash posit that certification standards "provide nonrival but potentially *excludable* benefits to members."[27] Crucially, by establishing high barriers to entry (firms

[20] The agency primarily responsible for nuclear safety (China's NNSA) is not even its main representative to the IAEA, which is the intergovernmental organization that oversees nuclear safety at a global level. Xu 2014.
[21] Bunn and Heinonen 2011.
[22] Johnston 2008; King and Lenox 2000.
[23] Buthe and Mattli 2011; Berliner and Prakash 2014.
[24] Abbott and Snidal 2013.
[25] Braithwaite 2006; Büthe 2010.
[26] Büthe and Mattli 2011; Chu 2020; Drezner and Lu 2009.
[27] Potoski and Prakash 2005. Emphasis ours.

must pay tangible costs to join the club and adhere to its standards), these certification clubs deny benefits (positive brand reputation) to non-members.[28]

The International Organization for Standardization (ISO) 14001 certification exemplifies the certification club approach to international private regulation. As the gold standard for environmental management systems, an ISO 14001 certificate provides an international seal of approval for a particular firm's environmental practices, incentivizing reluctant firms to join the club.[29] These firms are willing to pay the costs of joining the ISO 14001 club — members open themselves to third-party audits and moderately sized facilities can spend $1 million to comply with the standard — to access positive branding benefits and relieve pressure from civil society groups directed at non-certified firms.[30]

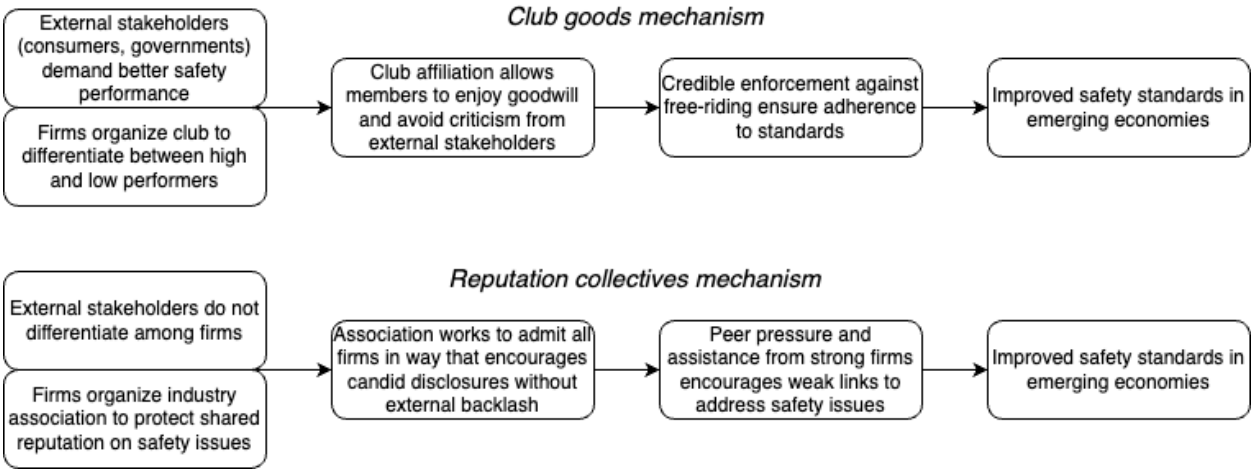
Clearly, the club framework provides a useful explanation for industry-sponsored voluntary programs across a variety of fields; however, is this the only way through which global private regulation produces improved safety regimes in developing countries? This article proposes another causal mechanism centered on "reputation collectives."[31] For industries in which an accident in one company damages the reputation of all others, firms are driven to pursue self-regulation initiatives because they are bound to a shared fate.[32] For example, after the Three Mile Island accident, Bill Lee, president of a major U.S. utility company, spearheaded the creation of the Institute of Nuclear Power Operations (INPO), which is often held up as an exemplary model for industry self-regulation. In a speech after the accident, Lee aptly captured the notion of an industry's collective reputation when he stated that all nuclear power plants were "*hostages of each other*."[33]

Under the reputation collectives model, industry associations advance global safety standards through a process that diverges from certification clubs (Figure 2). First, we theorize that these associations treat industry reputation as a *public good*, not a club good. The key difference is that, for associations managing the "hostages of each other" effect, industry reputation is ***nonexcludable***.[34] Unlike with certification standards, the benefits attached to WANO's efforts to improve the nuclear industry's image cannot be excluded from nonmembers. In the same way, members of WANO are not protected from mishaps involving nonmembers, as all firms in this industry are painted with the same brush.[35] This is why reputation collectives aim for universal membership.

---

[28] For studies of club models in international financial regulation, see Tsingou 2015.
[29] Prakash and Potoski 2006.
[30] Potoski and Prakash 2005.
[31] Related studies use the term "reputation commons" or "intangible commons." Barnett and King 2008. This creates some confusion by suggesting that industry reputation functions as a common-pool resource (rival but non-excludable), which does not accurately describe the mechanics at work in our theory.
[32] Barnett and King 2008, 1152; Ostrom 1990.
[33] Emphasis mine. Cantelon 2016, viii.
[34] For both certification clubs and reputation collectives, industry reputation is non-rival because if one firm enjoys positive reputational benefits, it is still available for another firm to benefit from.
[35] Interestingly, all nuclear power plant operators are members of WANO. This provides another contrast with the club goods approach. Potoski and Prakash write, "If membership is universal, the club does little to distinguish environmentally progressive members" (2005, 236). Our argument builds on Prakash and Potoski's section on green

Figure 2: Two Mechanisms for International Private Regulation



Second, while the club goods mechanism enables non-governmental organizations, regulators, and customers to differentiate between in-club and out-club firms ("regulation from the outside"), reputation collectives refrain from public naming and shaming ("regulation from the inside").[36] In their study of voluntary environmental programs, Prakash and Potoksi write, "Clubs provide stakeholders with a low-cost tool to differentiate environmentally progressive firms from laggards so that they can shower goodwill on the leaders, and heap scorn and punishment on the laggards."[37] This approach is less effective for reputation collectives because publicized scorn on laggards rebounds to everyone. Instead, industry associations seek to admit laggards and exert peer pressure in a way that protects them from external backlash.

To flesh out this second set of differences, consider INTERTANKO, an association of independent tankers which formed after the *Torrey Canyon* oil spill in 1967, caused by a supertanker wreck on the coast of the United Kingdom. Facing shared pressures from governments and environmental groups — as exemplified by strict global regulations imposed on all ship owners after the spill — INTERTANKO does not establish strong divisions between in-club and out-club firms.[38] The association monitors and benchmarks the safety performance of the tanker industry, but this information is only available to members — not the public, NGOs, or government actors.[39]

Third, in reputation collectives, weak links heavily shape the industry's shared image, regardless of whether these poor performers are members of the self-regulatory association. Thus, in

clubs with universal membership, which they describe as "an industry's response to its own collective reputation problem" (2006, chapter 2 typologies).

[36] Gunningham and Sinclair 2017, 142.

[37] Prakash and Potoski 2006, 18.

[38] According to a presentation by the managing director, INTERTANKO covers 80 percent of the independent oil tanker fleet. Swift 2008.

[39] Email communication with Phil Blanshard, external relations manager at INTERTANKO.

these settings, firms with leading safety performance should subsidize efforts to raise the standards of lagging firms.[40] This crystallizes another distinction between clubs and reputation collectives. Clubs are highly concerned with free-riding; they restrict access to membership benefits unless firms meet particular safety standards. In reputation collectives, however, free riding is self-defeating, as the weak link's poor performance is as damaging to its own reputation as it is to those of other firms.

Euro Chlor, the association of European chlorine producers that aims to limit accidental releases of chlorine, illustrates the differences between clubs and reputation collectives on dealing with free-riders.[41] In 2007, the more active Euro Chlor members sought to prevent less engaged firms (that did not participate in safety meetings or report their incidents) from accessing certain group benefits such as best practices manuals. As two management scholars write, this action to remove free riders meant that "information needed to enhance private reputations was made a *club good*, and this move could have created, in effect, two groups in the eyes of the stakeholders."[42] In short order, however, chlorine producers realized that "the biggest threat to their assets was not that the smaller firms could access their collective efforts to produce codes of conduct and guidelines 'for free,' but rather that the weakest firms were not making progress."[43] In other words, Euro Chlor recognized that it was a reputation collective. Reversing course, Euro Chlor turned its efforts toward helping weak links address their safety issues by facilitating plant visits from high-performing firms.

Our theory's scope is limited to associations that govern industries with shared safety reputations. Among the 458 international industry associations in operation, many do not take on regulatory functions, concentrating their efforts instead on lobbying for particular policies (e.g., the Computer & Communications Industry Association's advocacy on copyright and content moderation issues).[44] Other associations do set quality and safety standards, such as the Global Cashew Council, but these operate more like certification clubs. To better specify the range of industries to which our argument applies, we tabulated ten high-risk technological domains in which an accident at one firm damages the overall industry's safety reputation. For each of these industries, we then identified a candidate reputation collective (Table 1).

The industries that fall within our argument's scope meet two conditions. First, they are high-risk: the catastrophic effects of accidents means that firms must fiercely guard their perceived safety reputations. Second, a firm's safety reputation is interdependent with other firms in the same industry. On the first condition, we cross-referenced Perrow's *Normal Accidents*, which studied high-risk technologies across a diverse set of industries, with a UN working group report that identified

[40] Fauchart and Cowan 2013.
[41] Euro Chlor's members represent 97 percent of Europe's chlorine and sodium hydroxide production capacity.
[42] Fauchart and Cowan 2014, 535. Emphasis ours.
[43] Fauchart and Cowan 2014, 535. Research on the impact of Responsible Care on environmental performance has found that poor performers were more likely to improve than high performers after joining the initiative. King and Lenox 2000.
[44] Ronit 2022, 64.

technological hazards that posed global risks. As for the second condition, in some of these domains, such as aviation, chemical, and nuclear power, there is empirical consensus that a serious accident affects all firms in the industry.[45] In other domains, the presence of spillover effects is disputed. For instance, researchers have found that the Deepwater Horizon accident's negative impact on BP's stock market performance did not spill over to other oil and gas firms.[46] We still included offshore oil drilling in our list because there is substantial evidence that oil and gas firms perceive accidents like Deepwater Horizon as an industry-wide threat.[47]

Table 1: Scope Conditions (Technological Domains)

Domains	**Reputation collective candidate**
Chemical plants	International Council of Chemical Associations (Responsible Care initiative)
Many chemical sub-industries	World Chlorine Council
Maritime transport systems	INTERTANKO
Space ventures (launch service suppliers, spaceflight companies, satellite operators, etc.)	The Consortium for Execution of Rendezvous and Servicing Operations (CONFERS)
Nuclear power plants	World Association of Nuclear Operators
Biotechnology labs	Biotechnology Innovation Organization
Aviation systems	International Air Transport Association
Underground mining	International Council of Mining and Metals
Offshore oil drilling	American Petroleum Institute's Center for Offshore Safety
Artificial intelligence models (potential)	Frontier Model Forum

III. Research Method

To evaluate our explanation for how international industry associations help advance safety improvements in emerging economies, we investigate developments in China's nuclear, aviation, and

[45] Barnett 2007.
[46] McGuire et al. 2022.
[47] For example, in Deepwater Horizon's aftermath, oil and gas firms banded together to create a Center for Offshore Safety under the American Petroleum Institute that has taken on a significant rule-making and monitoring role in safety standards for offshore oil and gas exploration and production. Nieves-Zárate 2023. We are grateful to Aseem Prakash for feedback on this section. The supplementary appendix details the procedures we used to construct this list.

chemical industries. In all three cases, a global industry association incorporated Chinese firms into voluntary safety programs, and China experienced a significant reduction in the rate of dangerous incidents. These cases provide fertile ground for differentiating between the certification club and reputation collective mechanisms, as the *cause* (the emergence of a global private regime that regulates safety) and *outcome* (emerging economy's improvement in technological safety) are both present, which is in line with guidance on case selection strategy for process-tracing.[48]

While other high-risk technological domains also warrant in-depth analysis, there is empirical consensus that, in these three industries, one firm's accident damages the safety reputation of all other firms.[49] As the supplementary appendix details, the presence of spillover effects is disputed in other domains such as offshore oil operations. As for some high-risk technologies in the AI and space domains, the effects of an accident on the industry's aggregate reputation are unclear, and international industry associations oriented around safety have only recently emerged.

Moreover, our focus on China allows for a particularly difficult and useful test for the reputation collective mechanism. As other studies have found, mobilization to protect shared industry reputations is more challenging when firms face significant differences in geography, interests, and culture.[50] If our theory holds for engagement between Chinese firms under party-state capitalism and three international industry associations based in Western democracies with free market economies, then it should also apply in other contexts where collective action is much easier. Moreover, since newly industrializing economies ruled by authoritarian regimes do not possess the domestic institutions typically associated with effective governance of safety risks, it is more feasible to isolate the effects of international forces.

Our empirical analysis is grounded in several expectations derived from the theoretical framework. We anticipate that international industry associations will be driven by a commitment to enhancing safety practices among Chinese firms, motivated by the desire to uphold the global industry's shared reputation. This dynamic is expected to lead Chinese firms to recognize their collective responsibility in maintaining this reputation. Furthermore, by subjecting Chinese firms to positive peer pressure on safety issues, these associations are likely to encourage the adoption of safety standards that exceed "lowest common denominator" requirements.

In each case, we also test whether the evidence matches three observable implications predicted by each of the two mechanisms (Table 2). If the reputation collective mechanism is active, in each association's engagement with Chinese firms, it should manage industry reputation as a public good, recognizing that benefits and harms are not excludable to nonmembers. In addition, reputation collectives strive for universal membership and use peer pressure to protect lagging firms from backlash. In contrast, clubs differentiate between members and non-members, enabling

[48] Beach and Pederson 2013.
[49] Barnett 2007.
[50] Barnett 2006.

external stakeholders to praise leaders and shame laggards. Lastly, if the impact of international private regulation on Chinese firms' safety practices adheres to the certification club pathway, associations should address free-riding by restricting benefits when firms do not meet requirements. By comparison, reputation collectives concentrate on helping laggard firms improve safety, with high-performers supporting weak links.

Table 2: Two Mechanisms of Global Private Regulation

Mechanisms	*Excludability of reputation*	*Form of peer pressure*	*Approach to weak links and free-riders*
Certification Club	Treats industry reputation as club good	External naming-and-shaming	Restricts access to membership benefits
Reputation Collective	Treats industry reputation as public good	Internal benchmarking	Help laggard firms improve performance

The following cases draw on a diverse range of materials, including Chinese-language sources, quantitative data, and expert interviews. To reconstruct interactions between global industry associations and Chinese firms, we relied on underutilized Chinese sources, including annual reports from domestic industry associations such as the China Petroleum and Chemical Industry Federation, trade journals such as *China Civil Aviation Report*, and leading safety science publications such as the *China Safety Science Journal*. To comprehend relationships between the Chinese nuclear industry and global peers, we analyzed 263 international engagements between 2008 and 2022, as recorded in the China Nuclear Energy Yearbook. This was supplemented by 157 reports on WANO's engagements in China from a Chinese Atomic Energy Authority database of more than 7,000 news articles published between 2001 and 2024. These insights are further enriched by interviews with experts and former officials knowledgeable about the efforts to integrate Chinese firms into industry-led safety initiatives in the nuclear, aviation, and chemical domains.[51]

[51] The supplementary appendix contains a full list of interviews.

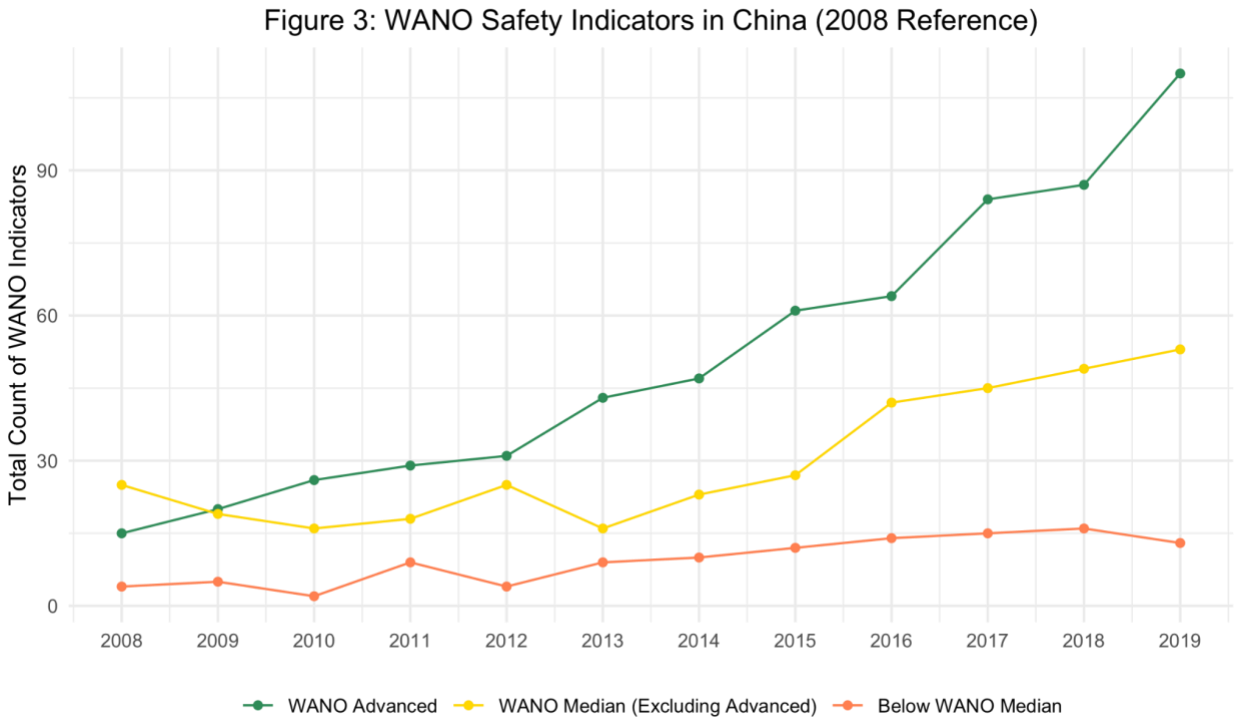
IV. Empirics

Nuclear Case (1987-2016)

Since construction began on its first nuclear reactor in 1985, China has achieved impressive results in nuclear safety. As of the end of 2020, Chinese nuclear power plants have operated safely and stably for a total of 407 reactor-years, without experiencing any nuclear accidents that exceeded Level 2 on the globally accepted International Nuclear Event Scale (INES).[52] In a comprehensive review of China's regulatory framework for nuclear safety in 2016, the IAEA concluded, "Since 2010, with careful consideration of the recommendations and suggestions made by the IAEA review team, and incorporating lessons learned from the Fukushima nuclear accident, the Chinese government has brought its nuclear and radiation safety regulation up to a new level."[53] Andrew Kadak, a MIT Professor of Practice in Nuclear Engineering who has served on safety oversight boards at Chinese nuclear power plants, states, "The safety performance of the Chinese reactors has been quite good, with no known abnormal releases of radioactivity or events that have threatened the safety of the reactor core."[54]

This is not to say that China's nuclear safety record is spotless. One issue is the extent to which Chinese government reports on nuclear incidents can be trusted.[55] The largest database on nuclear incidents and accidents does not cover Chinese operators because Chinese authorities limit public disclosure of operational mishaps.[56] Additionally, corruption cases have called into question the extent to which nuclear executives prioritize safety.[57] Going forward, informed observers, including the former director of the National Nuclear Safety Administration, have expressed serious concerns about China's ability to maintain operational safety amidst its aggressive expansion of nuclear power plant construction.[58]

[52] For context, at the end of 2020, worldwide cumulative operating experience in nuclear power was over 18,000 reactor-years. Countries that have experienced more than two accidents above INES 2 include Canada, France, Germany, Japan, Russia, the UK, and the United States. Chong 2013.
[53] IAEA 2016.
[54] Kadak 2006.
[55] The Chinese government has avoided reckoning with the health risks of past nuclear tests in Xinjiang, which were carried out without adequate safety measures. Meralli 2009.
[56] Email communication with Ali Youb, postdoctoral researcher at the MIT Department of Nuclear Science and Engineering, June 22, 2023. See also Ayoub et al. 2021.
[57] Osnos 2011.
[58] Reuters 2009. Other factors that will shape China's nuclear safety approach include the supply of personnel with necessary skills to supervise and inspect nuclear power plants as well as whether better standardization of reactor designs can be achieved. Yi-chong 2010.



Source: China Nuclear Yearbooks 2009-2020.

Nevertheless, WANO performance indicators bear out China's significant improvements in nuclear safety over time. Regarded by experts as carefully chosen and reliable, these metrics track unplanned scrams, leaks and radiation exposures, incident rates, and other factors that correlate with nuclear safety.[59] As relayed in the introduction, of the safety performance markers reported by Chinese nuclear power plants, the proportion that exceed the WANO Advanced standard (75th percentile) has nearly doubled since 2008.[60] As additional Chinese nuclear plant units became operational, there has been an increase in the count of indicators that fall below the WANO Median (50th percentile). However, as Figure 3 depicts, the overall trend is a strong and growing majority of safety performance indicators that land above either the median or advanced level, which shows that even as China's nuclear power capacity has expanded, operators still made progress in nuclear safety relative to their international peers.

How did China realize these substantial nuclear safety gains? We argue that international private regulation, facilitated through WANO as a reputation collective, played a critical role in

[59] Interview with nuclear energy historian Phil Cantelon, phone, 10/10/23; email communication with Ali Ayoub, 7/25/2024.

[60] WANO 2019. All Chinese nuclear power plants track WANO's five key safety indicators: operating period forced loss rate, collective radiation exposure, total industry safety accident rate, safety system performance indicator, and unplanned total scrams per 7,000 hours critical (the first four were established in 2007; the last was added in 2013). For temporal consistency, only the first four indicators are included in Figure 3. Similar to Figure 1, we apply 2008 WANO Median and Advanced standards to generate the total counts in Figure 3. A floating standard version of Figure 3 is available in Appendix Figure A2 and yields similar results.

aiding Chinese nuclear operators achieve higher safety standards. Jolted into action after the Chernobyl tragedy, 144 nuclear operators established WANO in 1989 to prevent future accidents.[61] Since its founding, WANO has enjoyed universal membership, which means that every nuclear power plant participates in the international industry association. To raise the bar on nuclear safety, WANO supports information exchanges on best practices and incident notifications, safety indicators, and peer review plant evaluations.[62]

Since its inception, WANO has worked with Chinese operators to improve nuclear safety in China. In 1987, two years after China started building its first nuclear power plant, Chinese operators were invited to the initial WANO meeting that led to the formation of the organization.[63] WANO's outreach and engagement with Chinese operators have successfully ingrained its model of peer pressure and industry self-regulation in the minds of Chinese industry leaders. At a national conference on nuclear safety, Zhang Huazhu, the Chairman of the CNEA (China's nuclear industry association) explained:

> "The international nuclear power industry has reflected deeply on the nuclear accidents at Three Mile Island in the United States and Chernobyl in the former Soviet Union…Over the past 30 years, the self-assessment and operational experience feedback activities carried out by the INPO in the United States…have complemented the independent regulation by the U.S. Nuclear Regulatory Commission, significantly enhancing the safety and economy of nuclear power plants across the United States. WANO, drawing on INPO's methods, has planned 'four backbone' lines of work: peer review, operational experience feedback, technical support and exchange, and professional and technical development."[64]

Both of China's major state-owned nuclear operators, the China National Nuclear Corporation (CNNC) and the China General Nuclear Power Corporation (CGN) became WANO members before the start of their commercial operations in 1994.[65]

WANO's safety practices have also been incorporated into Chinese regulations. In 2002, the Commission for Science, Technology and Industry for National Defense (COSTIN) issued China's first official policy on the adoption of WANO standards and peer reviews.[66] The policy led to the formation of the Operational Assessment Committee (OAC) for nuclear power plants,[67] which mandated that each nuclear plant should undergo an external peer review every 2 to 3 years through either the OAC, WANO, or the IAEA.[68] Shortly after Qinshan Phase II entered into commercial

[61] Chang 1999, p.13.
[62] Cantelon 2016, p.185.
[63] Eckered 1987.
[64] CNEA 2010, p.281.
[65] IAEA 1997.
[66] COSTIND 2002.
[67] NNSA 2004.
[68] Ding 2005.

operation in 2002, the OAC conducted its first peer review at the plant,[69] which was followed by a WANO peer review in 2003 and a WANO follow-up visit two years later.[70]

Although Chinese operators work with other entities on peer reviews, WANO's reviews are deeper and more extensive than those conducted by the IAEA and by Chinese state regulators. To begin, WANO facilitates the vast majority of reviews . From 2016 to 2018, Chinese nuclear power plants received 29 WANO peer review activities, compared to 3 IAEA review missions.[71] This reflects a funding and human resource disparity acknowledged by former IAEA head Hans Blix.[72] Second, WANO peer reviews can probe technical details that IAEA-facilitated peer reviews do not cover. Commenting on the IAEA's process, Trevor Findlay, an expert on nuclear governance in the Asia-Pacific region who regularly participates in global exchanges on nuclear safety, states, "These peer reviews don't get anywhere close to the technology."[73]

Engagements between WANO and Chinese nuclear operators have elevated safety standards above those mandated by Chinese national legislation and international legal commitments. For instance, CNNC uses WANO's eight principles (and 57 related attributes) of nuclear safety culture to internally assess its nuclear safety culture. This evaluation model is also embedded in WANO's pre-startup review (PSUR) process, a two-week procedure in which a 15-person team of WANO staff and industry peers visit a new unit. In 2010, WANO established a branch office in China to assist the growing number of nuclear plants that had scheduled such reviews; a year later WANO opened another satellite office in Hong Kong to support PSURs.[74]

Both of these processes went beyond what Chinese policy and IAEA standards required. The Chinese government did not issue a policy statement on nuclear safety culture until December 2014, which proposed eight principles. The IAEA does provide a similar service to PSURs through its pre-operational safety review team (OSART) missions. However, these are not mandated for new units, and pre-OSART missions are not as extensive as WANO's PSURs with respect to "the conduct of crew performance observations in the control room simulator and in review of significant operating experience reports from the industry."[75]

Non-excludable vs. excludable reputation

In its engagement with Chinese firms, did WANO treat industry reputation as a non-excludable or excludable good? Confronting the aftermath of the Chernobyl disaster, the nuclear

[69] Gu 2004.
[70] Gu 2005.
[71] Authors' analysis of China's National Reports for the Convention on Nuclear Safety.
[72] Cantelon (2016, 13) relates: "Blix immediately saw the benefits of a new international organisation… he did not have the resources to expand the OSART [pre-operational safety review team] programme and was unlikely to get additional funding for it in the future. 'If the utilities can do it themselves and we can have some access to the results,' he said, 'I'll be able to say to the international community that we're supporting this utility activity.'"
[73] Interview with Trevor Findlay, Zoom, 12/25/23.
[74] Cantelon 2016.
[75] Brumfield 2012, p.3.

industry founded WANO on the principle that all operators are hostages of each other. Determined to ensure participation from all nuclear operators in 31 countries for its initial meeting in 1987, WANO managers labored to navigate demands from Chinese and Taiwanese utilities regarding the placement of national flags around the table. Eventually, Taiwan Power and the Chinese National Nuclear Corporation agreed to attend the meeting under their company affiliations, not their national ones, and no flags were present.[76]

In 2011, the Fukushima accident provided a grave reminder that the reputation of one firm could not be uncoupled from the entire nuclear industry, as government officials in many countries withdrew nuclear energy investments. WANO established a Post-Fukushima Commission of senior utility executives from 12 countries, including Ligang Gao from the China Guangdong Nuclear Power Group (CGNPG).[77] At the next biennial meeting general meeting in October 2011, held in Shenzhen, China, WANO members adopted the commission's recommendations to strengthen their safety commitments, including an increase in the frequencies of peer reviews, a requirement for pre-startup reviews at each new plant, and a ranking system based on INPO's approach that would place additional pressure on safety laggards.[78]

The involvement of Chinese firms in the commission and as hosts of that critical Shenzhen meeting was a product of WANO's recognition that the industry's safety reputation would increasingly be dependent on China's nuclear industry. At that time, CGNPG (now known as CGN) boasted the world's largest amount of nuclear power capacity under construction.[79] In the early 2010s, when two new Chinese operators, State Power Investment Corporation and China Huaneng Group, entered the field, both participated in WANO PSURs and safety culture seminars while their plants were still under construction.[80] At a speech in Beijing in 2015, Joel Bohlmann, Deputy Director of WANO London Center, reiterated the industry's shared safety reputation:

> "When a nuclear accident occurs, the public tends to perceive it as a failure of nuclear technology rather than a failure of a specific operator or country. This public perception makes us realize that all nuclear power professionals worldwide must defend the safety of this industry because an accident in one place affects confidence in all nuclear facilities."[81]

Internal benchmarking vs. public naming and shaming

Besides the establishment of shared reputation, another key component of the reputation collective is the capacity of industry associations to internally generate peer pressure while

[76] Cantelon 2016, 15.
[77] Felgate 2012.
[78] Cantelon 2016, 199-202.
[79] Cantelon 2016, 214.
[80] SPIC started commercial operation in 2018. CNEA 2022, p.114; CHNG started in 2023. Yu 2024.
[81] CNEA 2016, 388. The speech was given at the first World Nuclear Energy Development Forum organized by the CNEA. Representatives from the US, the UK, France, and Japan, the IAEA, and WANO participated and spoke at the conference.

safeguarding the industry from external backlash. The best way to visualize this internal pressure is to consider what happens when the leaders of nuclear operators meet with their counterparts at WANO meetings. WANO has adopted INPO's internal grading system for each plant based on its safety performance, from category one (the best rating) to five (the worst).[82] At its Biennial General Meeting, WANO distributes the grades to all the CEOs in a closed session.[83] If this process resembles INPO's, it is a "remarkable ritual" of governance by embarrassment.[84] One CEO described the INPO process:

> "All the CEOs are gathered in a big room with Zack Pate [INPO's President], and he flashes up the most recent evaluation numbers for each of the utilities by name. That's the only time we learn how our peers are ranked, and it kind of hits you right between the eyeballs. The first slide has all the number ones, the best-rated utilities. Then come the number twos…and then you get down to the fours and the fives. And after some pretty frank discussions of their problems, those guys are feeling rather uneasy to say the least."[85]

Notably, this candid feedback is kept in-house. Recounting her experience at INPO meetings, a former chair of the U.S. Nuclear Regulatory Commission said that she would attend the celebratory dinner to honor the best performers but was never invited to the next morning's "name-and-shame" breakfast.[86]

In line with the reputation collective mechanism, discretion, not public transparency, is critical to WANO's governance regime. Each member of WANO signs a formal confidentiality agreement, which safeguards information shared among members and describes protections for peer review results, assessment ratings, and other documents.[87] As one Union of Concerned Scientist report states, "WANO is not accountable to governments or the public, and it performs the bulk of its work out of public view."[88] After the Fukushima accident, WANO governing boards did consider whether to shift toward the IAEA's approach of making peer review reports open to the public. Ultimately, WANO decided that "it could be transparent about why and how it works, but not about what it finds."[89] It appears that China's nuclear industry association has also grappled with this balance between transparency and trust. In 2012, CNEA published a global ranking of Chinese plants in terms of WANO indicators; the following year, it removed the rankings and has not disclosed them since.[90]

---

[82] Prozesky 2020.
[83] Cantelon 2016, One WANO chapter.
[84] Rees 1994, 104.
[85] Quoted in Rees 1994, 104-105.
[86] Interview with Allison Macfarlane, Zoom, 4/5/24.
[87] WANO 2024.
[88] Gronlund et al. 2007.
[89] WNN 2017.
[90] Since the first release of the China Nuclear Energy Yearbook in 2008, only the 2012 Yearbook published the global rankings of Chinese nuclear power plants.

To be fair to the certification club framework, some of the Chinese nuclear industry's reports that contain WANO benchmarks could be used to expose industry laggards to public scrutiny. Compared to their counterparts in most countries, CNEA provides slightly more transparency on safety performance through its China Nuclear Energy Yearbook. In addition to the actual scores, the yearbook also publishes the number of indicators for each plant that sit above or below the WANO median level.[91] Two caveats apply to this limited evidence that supports the certification club mechanism. First, as the above sections demonstrate, the yearbook figures provide a broad sense of where Chinese companies stand but they do not give specific rankings. Second, it is likely that CNEA feels more comfortable sharing these safety indicators because Chinese nongovernmental organizations have limited capacity to name and shame companies in strategic sectors.[92]

Assistance to weak links vs. exclusion of free riders

If interactions between WANO and Chinese firms aligned with the expectations of certification clubs, then the association should have excluded safety underperformers. Instead, WANO was committed to assisting weak links, including firms that hesitated to embrace WANO practices. For instance, CNNC's Qinshan plant, which did not adhere to WANO standards, experienced a safety incident in 1998, in which plant engineers discovered extensive wear on the reactor vessel's internal surface and damage to several fuel rods.[93] Instead of seeking to prevent the Qinshan plant from accessing association benefits, WANO worked with management to develop a Five-Year Plan for the plant to reach safety indicators at the WANO Median level by the end of 2005.[94] To reach the goal, the management team at Qinshan "enhanced technology exchanges with foreign peers" while adopting "international standards and WANO's evaluation metrics."[95]

The pre-startup review process supplies additional evidence of how WANO enabled leading firms to provide safety assistance to firms that did not have any operational experience. Todd Brumfield was part of the WANO team that established a Hong Kong office to manage procedures for pre-startup reviews of new nuclear plants in China. On one visit to a plant in Ningde, which was preparing to begin commercial operation, he brought an international team of experienced managers from Britain and South Africa. When he asked the plant's backup plan in case the computer monitors malfunctioned, the Chinese team pointed to a remote shutdown panel. After Brumfield inquired about the procedures to manage the panel, he recalls that it took the operators 30 minutes to find the relevant materials ("and wipe the dust off").[96] These types of engagements in the pre-startup review process helped inexperienced Chinese firms develop better safety culture and practices.

[91] See Appendix Table A3 in supplementary appendix.
[92] Utting 2003.
[93] NRC 2001, p.4-5.
[94] CAEA 2006.
[95] Zhang and He 2003.
[96] Interview with Todd Brumfield, Zoom, 7/31/24.

This commitment to assisting weak links was tested after the Fukushima accident, which placed pressure on WANO to ostracize problematic plants that did not comply fully with WANO standards. In essence, if it followed this route, WANO would have converted into a certification club. Instead, in an interview with *Nature* later that year, WANO Managing Director George Felgate reiterated the organization's reluctance to abandon safety laggards. "I cannot imagine it ever coming to the point where we would expel a member from WANO. Peer pressure is a very powerful tool in our industry," he stated.[97]

Alternative factors

It is worth reiterating that China's nuclear safety progress occurred in the absence of a powerful intergovernmental organization that imposed binding standards or publicly named and shamed weak performers. Jack Barkenbus, in an *International Organization* article published the year after the Chernobyl disaster, suggested that the IAEA would likely need to exert more social pressure in public settings by "publicizing the actions (or inaction) of a low performer, and thereby significantly affecting public opinion in that state and its neighboring countries."[98] Yet, the IAEA's Convention on Nuclear Safety, the closest instrument to a legally binding treaty in this domain, does not mandate compliance with IAEA safety standards.[99] According to Trevor Findlay, "in an ideal and logical world" of nuclear governance in the Asia-Pacific region, a single body would "issue binding nuclear safety and security standards" and "work to increase transparency and public awareness."[100] Indeed, the developments described in this case diverge from the expectations of scholars about how international institutions could raise safety standards in nuclear power producing countries.

Nor is this a story about the Chinese central government implementing top-down safety reforms. As China was entering an accelerating pace of nuclear power development in the late 2000s, nuclear safety regulation in China considerably lagged behind the industry's rapid growth. In 2010, the IAEA's Integrated Regulatory Review Service, a mission focusing on a country's regulatory readiness in nuclear safety, emphasized that China's top priority should be to develop a comprehensive nuclear safety law.[101] However, Beijing did not issue China's Nuclear Safety Law until 2017[102] after 37 nuclear power units were already in operation.[103] As Trevor Findlay notes, "[China has] used the IAEA standards as a guide to writing their own legislation. But these standards are the lowest-common denominator."[104] Additionally, it is well-established in the existing literature that an independent government agency of any kind would be against the core interest of the

[97] Butler 2011.
[98] Barkenbus 1987, 488.
[99] Montjoie 2015.
[100] Findlay 2010.
[101] IAEA 2010, p.8.
[102] MEE 2017.
[103] CNEA 2018, p.104.
[104] Interview with Trevor Findlay, Zoom, 12/25/23.

Chinese regime, which is established upon the nomenklatura system in which all major positions in the state and state-owned enterprises are appointed by the CCP.[105]

Relatedly, China's advances in nuclear safety have not been driven by material-based enforcement mechanisms such as civil penalties and fines. The caps on the liability of Chinese nuclear operators (for a potential accident) are much lower than those established by the U.S. and other countries.[106] In fact, one of the major gaps in China's engagement with the international regime on nuclear safety is its failure to ratify two protocols on compensation for nuclear damage.[107]

In sum, the development of self-regulation through the promotion of industry-led safety standards and peer reviews has been a key factor in China's nuclear safety progress. Crucially, however, engagements with WANO did not enhance the safety performance of Chinese operators through the certification club mechanism, which provides *excludable* benefits by differentiating the performance of members from non-members. Instead, WANO exposed Chinese operators to the type of peer pressure that forms in industries in which safety reputation is *non-excludable* from weak performers. This influence channel is characterized by three distinctive features of WANO's engagements: shared reputation, backlash protection, and laggard assistance.

Civil Aviation Case (1990-2008)

Over the past fifteen years, by some metrics, it has been safer to fly on Chinese planes than aircraft in some of the safest aviation systems in the world, including that of the United States. From 2008 to 2021, China's accident rate (per million departures) of large commercial aircraft was lower than the U.S.'s rate. Before the crash of a China Eastern Airlines flight in 2022, Chinese carriers had avoided a major incident for 100 million consecutive flight hours, a stretch of twelve years.[108]

China's current air safety record represents a substantial improvement from the 1990s and early 2000s when fatal disasters were an all-too-common occurrence. Using data on over 6,000 incidents in China's civil aviation industry, two researchers at the Civil Aviation University of China found that the incident rate declined from 183.3 incidents per million flight hours in 1994 to 28.4 incidents per million flight hours in 2008 — a mark that has held relatively steady since.[109] Over the 2008-2017 period, China's safety performance placed it among the lowest-risk group of aviation nations alongside the U.S. and Western European countries, based on probabilistic models of air traveler mortality risk developed by MIT Professor of Statistics Arnold Barnett.[110]

[105] e.g. Pearson 2007; Hsueh 2011; Gilly 2012; Yasuda 2021.
[106] Jing and Faure 2012.
[107] Andrews-Speed 2020.
[108] Lau 2022.
[109] He and Sun 2023.
[110] Barnett 2020. See Appendix Figure A3 for more details on China's declining accident rate in civil aviation.

Founded in 1945, the International Air Transport Association (IATA) is the primary industry association for the world's airlines. In addition to advocacy on behalf of the industry, IATA also promotes global safety standards and recommended practices by managing operational audits, sharing data on incidents and risks, and conducting safety management training. Since it was founded with 57 member airlines from 31 countries, IATA has expanded to 320 member airlines from 120 countries around the world.

Broadly speaking, the history of IATA-China engagement tracks well with the expected operations of a reputation collective. China's shaky air safety record in the early 1990s prompted the IATA to work with the Civil Aviation Administration of China (CAAC) and provide technical assistance to China's aviation industry.[111] China's famed "Big Three" airlines — Air China, China Eastern, and China Southern — became IATA members in 1993, with three regional airlines joining shortly after.[112] During this period, English language proficiency was a bottleneck to safety upgrades. In December 1995, IATA Director General Pierre Jeanniot relayed that China had "less English competency at the airline level than in any other country."[113] Since nearly all international aviation standards were in English, IATA translated its manuals and publications into Chinese.[114] In 1996, on CAAC's invitation, IATA provided an English language course for pilots and air traffic controllers to help them assimilate international air safety standards.[115]

In the late 1990s and early 2000s, faced with a climbing global accident rate and the September 11th attacks, IATA took more aggressive steps to combat the public perception that flying was unsafe.[116] To safeguard the entire industry's reputation, in 2001, IATA initiated the Internal Operational Safety Audit (IOSA) program, which aimed to establish a globally accepted safety evaluation system for airlines.[117] Later that year, it also established a safety trend evaluation and data exchange system (STEADES), a voluntary initiative to share safety incident data. In the following years, IATA presented the IOSA program at a "Regulatory Authority awareness session" with CAAC; in 2005, around eight Chinese airlines underwent IOSA audits, and four more Chinese airlines had contracts in place to complete IOSA audits in the following year.[118] IATA also sought to expand the global coverage of STEADES. By 2011, six Chinese airlines had joined the information exchange.[119]

---

111 Shughuart 1998, 13.
112 Reynolds 1995.
113 Reynolds 1995.
114 SCMP Reporter 1996.
115 Aviation Week & Space Technology 1996, 34; in conjunction with language services provider Berlitz, IATA assessed these two groups on their English proficiency. IATA 2006.
116 Mills 2016, 52.
117 IOSA built on the operational quality standards audit, which became a condition of IATA membership in 1999.
118 IATA 2006. This report only gives statistics on the Northern Asia region, which includes China, Taiwan, Mongolia, and North Korea. On the regulatory authority awareness sessions, see O'Brien 2004.
119 Authors' data on STEADES members list (as of 2011) available upon request.

These IATA initiatives encouraged Chinese airlines to adopt safety requirements that were more stringent than those set by the International Civil Aviation Organization (ICAO), the United Nations agency that manages civil aviation safety. According to *The Wall Street Journal*, after a crash in 2004, CAAC and IATA "worked out a separate cooperation pact." The report relates, "China became a pioneer in allowing IATA specialists to audit all airlines and in due course release their findings."[120] This embrace of IOSA audits indicates that Chinese airlines had adopted recommended practices that exceeded the baseline set by ICAO standards.[121] William Voss, who was the director of ICAO's Air Navigation Bureau at the time, recalls:

> "China became an early adopter of IOSA... It made a very significant effect because it was in some ways a more robust protocol than regulators could use. It's difficult to pass detailed regulations, and the protocols they could use in IOSA were derived from ICAO international standards but they could get far more granular in operational implementation."[122]

Evaluating the impact of Shandong Airlines's engagement with the IOSA program, a 2006 article published in a leading Chinese-language safety science journal highlighted that the airline built its safety management system by integrating "the IOSA operational safety audit standards formulated by the IATA."[123] Engagement with STEADES also allowed Chinese firms to benchmark their safety performance against their peers. After entering their raw data on incident rates, participants could analyze their relative deficiencies and strengths with comparison tables and charts.[124]

Shared reputation: Reputation collectives vs certification clubs

In addition to these general clues about how international private regulation supported China's advances in aviation safety, evidence from this case illuminates finer-grained distinctions between reputation collectives and certification clubs. First, IATA's outreach to Chinese firms demonstrated its recognition that the global aviation industry's reputation was non-excludable. Andy Pasztor, who reported on all major commercial aircraft crashes around the world for over two decades, is the veteran journalist who detailed the CAAC-IATA cooperation agreement. On the motivating factors, Pasztor comments:

> "The notion of a shared reputation was the genesis of the whole effort. Boeing and Airbus were not just looking at crashes in the U.S., they were looking at countries in the developing world — China, most obviously. They realized that a crash anywhere would result in a tremendous reputational fallout, from the perspective of the general public everywhere,

[120] Pasztor 2007. Relatedly, the CAAC became one of the ten regulatory authorities represented on the IOSA Oversight Committee. Sabec 2004.
[121] Mills 2016; Sabec 2004.
[122] Interview with William Voss, Washington DC, 5/21/24.
[123] Zhang et al. 2006.
[124] IATA n.d.

> regardless of what the airline was where the crash took place. The industry as a whole looks at safety more broadly."[125]

Unlike certification standards that aim to protect members from the reputation hazards of non-members, IATA realized that Chinese airliners' poor safety performance reflected on the industry as a whole.

The IATA's management of the IOSA program provides additional evidence of the non-excludability of this industry association's safety benefits. In 2005, IATA made the audit program's standards and recommended practices freely available to non-members.[126] At an ICAO conference in March 2006, reporting on how the IOSA could contribute to a global strategy for aviation safety, IATA highlighted that the program was open to everyone, "It is important to note also that over 20 per cent of the IOSA audits being conducted are done on non-Members of IATA. This clearly demonstrates that IOSA is a programme for all airlines."[127] The proportion of non-IATA members that take advantage of the IOSA continues to be significant. In 2014, about 35 percent of airlines that had recently completed this audit were non-members.[128]

Internal benchmarking vs. public naming and shaming

If the certification club mechanism was operative in this case, IATA membership should function as a tool for the general public and community organizations to applaud leaders and condemn laggards. There is some evidence of public name-and-shame tactics. For instance, the website airlineratings.com, one source of airline safety information that draws widespread attention, incorporates the IOSA program into its rankings of safest airlines. However, non-members of IATA can also pass IOSA audits, and these ratings have been criticized for being empirically dubious.[129] On the whole, IATA members do not advertise that they are safer than non-members. In fact, one report found that safety has "all but disappeared from" modern airline advertisements, in part because the "S-word" causes passengers to worry about the unpredictability of the overall commercial aviation industry.[130]

The development of STEADES provides further evidence of a reputation collective that seeks to protect laggards from external backlash. After the launch of STEADES in 2001, the CAAC and the Civil Aviation University in Tianjin worked closely with IATA to share incident reports that allow air carriers to benchmark their performance against their peers.[131] Contrary to the expectations of the certification clubs mechanism, IATA restricts access to STEADES data to safety regulators

[125] Interview with Andy Pasztor, phone, 4/16/24.
[126] Mills 2016.
[127] IATA 2006.
[128] IATA 2015.
[129] Barnett 2020.
[130] Linshi 2015.
[131] vsundhara 2009.

and air carriers out of "fear of misinterpretation by the media and the public."[132] Moreover, to ensure confidentiality, STEADES data is de-identified to foster a candid reporting culture.[133] Likewise, IATA does not make IOSA audit reports available to the general public, as contents are only released to airlines or regulators with the audited airline's agreement.[134]

Assistance to weak links vs. exclusion of free riders

Did IATA approach weak links like a certification club or a reputation collective? IATA's decision to make IOSA a requirement for membership serves as a good test for these mechanisms. In 2006, IATA demanded that all members conduct an IOSA audit by the end of 2007, which ultimately resulted in 21 firms leaving the association between 2006 and 2008. On the one hand, this development appears to substantiate a certification club's expected behavior toward weak links: restrict access to membership benefits when safety laggards do not meet requirements. IATA expelled airlines that did not begin the IOSA process (such as Albanian Airways) or failed to resolve audit findings (Rwandair Express).[135]

On the other hand, even as it enforced this membership requirement, IATA proactively assisted airlines with limited resources to meet IOSA standards. IATA's Partnership for Safety initiative distributed $3 million in funds between 2005 and 2007 toward awareness seminars on operational safety best practices as well as trial audits to pinpoint areas of improvement for individual airlines.[136] One of these week-long seminars was held in Beijing in 2007, as the program targeted developing regions such as the Asia-Pacific; IATA's North Asia regional team also organized many seminars and trainings to help Chinese airlines and the CAAC address gaps in their safety management systems.[137] All Chinese airlines completed IOSA audits and retained their IATA membership.

In fact, as further evidence of a reputation collective dedicated to helping weak links, a substantial number of the ousted firms eventually regained their IATA membership. We traced developments in all 21 firms after they lost IATA membership.[138] Nine airlines ceased operations around this time due to financial difficulties that were unrelated to IOSA issues. Of the 12 that

[132] Mills 2010.
[133] Mills 2010.
[134] IATA 2006.
[135] Schofield 2009.
[136] In line with the prediction of the reputation collective mechanism, IATA provided a channel for strong firms (in terms of safety performance) to subsidize the efforts of the weak to improve their standards. For example, industry leaders such as Boeing and Pratt & Whitney provided matching funds for this initiative. Hounsell 2008.
[137] Three additional trainings include: 1) an IOSA symposium in Urumqi (September 2012), in which IATA shared standards documents with CAAC on developing an integrated safety management system for airlines (China Civil Aviation Report 2012); 2) a joint training seminar, co-organized by the North Asia regional team and the IATA training and development institute, for the China National Aviation Holding Company (IATA 2006); and an interactive safety seminar in China in December 2005 (IATA 2006)
[138] For a table that specifies outcomes for all 21 firms, see supplementary appendix.

continued to operate, seven airlines rejoined IATA.[139] For example, after receiving assistance from IATA and other African airlines with stronger safety protocols, RwandAir Express (now known as RwandAir) successfully completed an IOSA audit in 2014 and regained IATA membership in 2015. In describing this process, Mr. Jean-Paul Nyirubutama, deputy CEO of RwandAir stated, "IATA's contribution to IOSA preparation was a game changer as a young and hitherto inexperienced team morphed into a performing and well prepared team ready to undergo the audit and to improve operational standards."[140]

Alternative factors

This case study's main objective is to uncover the particular pathways by which international private regulation contributed to China's progress in aviation safety in the years before 2008, not to provide an all-encompassing account of the outcome. Tracing these mechanisms helps uncover the influence of international aviation standards developed by private organizations and technical assistance from international industry associations.[141] It is also important to acknowledge that China's advances in aviation safety were a product of many other interrelated drivers, including reforms that strengthened CAAC's regulatory authority over aviation safety, binding international agreements, the technical upgrading of China's aircraft fleet, and the leadership of Yang Yuanyuan as CAAC director from 2002 to 2007.[142]

Still, in many of these alternative explanations, international private regulation plays an essential role, which makes it important to differentiate between the specific mechanisms at work. In John Yasuda's account of how strengthened regulatory control reduced China's aviation accident rate, key CAAC interventions relied on the assistance of international airlines and organizations.[143] To be sure, the main public regulatory agency in this space (ICAO) has played an important role in encouraging safety regulators to adopt IATA programs such as IOSA.[144] Nonetheless, it was IATA that established and implemented these audit and reporting programs, as ICAO lacked the capacity to do so on its own.[145]

Chemical Case (2002-2021)

Over the past two decades, China has made modest progress in reducing the number of accidents in its chemical sector. Analyzing chemical accident data for the 2004-2019 period, researchers at TU Delft's safety and security science group found a consistent decrease in the

[139] The five airlines that continue to operate without an IOSA audit own very small fleets (e.g., Air Marshall Islands, which owns one plane).
[140] Nyirubutama 2014.
[141] Keck 2000; Yasuda 2021; Eilstrup-Sangiovanni 2022.
[142] Yasuda 2024; Suttmeier 2008; Pasztor 2007.
[143] Yasuda 2024.
[144] Tony Tyler, former IATA Director General, once said, "IATA and ICAO are located across the street from each other in Montreal. And we share a long history of cooperation that continues to this day." Quoted in Ronit 2018, 78.
[145] Mills 2016. For another account that emphasizes the limited authority of ICAO's safety standards, see Eilstrup-Sangiovanni 2022.

number of accidents in China's chemical industry.[146] According to another study, hazardous chemical accidents in China declined by over 50 percent from 2015 to 2019.[147] In a 2019 feature, *Chemistry World,* the flagship magazine of the Royal Society of Chemistry*,* aptly captured the trend with the headline: "China makes slow progress on safety."[148]

It is important to not overstate these safety improvements in China's chemical industry. In December 2014, working with the United Nations Institute for Training and Research, Chinese experts based at Peking University and other institutions published a national profile of China's chemicals management system. Citing frequent occurrences of incidents, they assessed China's level of safety capacity with hazardous chemicals as "low."[149] Even as the frequency of accidents has declined, fatalities have only slightly declined from 2011 to 2018. China has seen two major chemical accidents in the past decade: a warehouse explosion in Tianjin in 2015, which killed over 170 people; and a 2019 accident at the Tianjiayi plant in Xiangshui county, which resulted in at least 78 deaths.[150]

In 1989, chemical industry leaders formed the International Council of Chemical Associations (ICCA) to steward the Responsible Care (RC) program, a voluntary initiative that encourages chemical companies to revamp safety and sustainability practices, at the global level.[151] At a UN international conference on chemicals management in 2006, ICCA launched a RC Global Charter, which committed signatories to share best practices and report safety performance measures. As of October 2021, this charter has been signed by more than 580 chemical firms, which comprise 96 percent of the world's largest chemical companies.[152]

The diffusion of RC practices to Chinese companies was a gradual process. In the early years, ICCA primarily relied on the Association of International Chemical Manufacturers (AICM), an industry group founded in Hong Kong in 1988 that represented Dow, Cabot, and other major multinational companies with chemical facilities in China. While AICM members could directly incorporate RC codes in their wholly-owned subsidiaries in China as well as their joint ventures with Chinese producers, another association, the China Petroleum and Chemical Industry Federation (CPCIF), represented the overwhelming majority of Chinese companies. In April 2002, the two associations signed an agreement to cooperate on RC capacity-building and training programs.[153] After years of sparse activity, interspersed with the occasional RC promotion conference, ICCA

[146] Chen and Reniers 2020. The number of chemical accidents decreased by 69 percent from 2004 to 2010; then, relative to the year 2011 (after a change in the statistical procedures for collecting accidents), the number of accidents in 2015 decreased by 54 percent; after another revision in classification methods, the number of accidents in 2018 represented a 22.1 percent decline from 2016.
[147] Zhou et al. 2022.
[148] Naidu 2019.
[149] Liu 2014.
[150] Kan 2019.
[151] In the years after the Canadian chemical manufacturers launched the Responsible Care (RC) program in 1985, more and more national chemical associations adopted the RC initiative.
[152] RCLG 2021.
[153] RCLG 2012. CPCIF 2022.

granted CPCIF observer status in 2011, and CPCIF eventually joined the RC leadership group in 2014.

ICCA's engagement with Chinese companies intensified alongside concerns that China's fast-growing chemical industry — which became the world's largest in 2011 — would outpace safety protections. ICCA confronted the necessity of "greater international acceptance of Responsible Care" because, as Professor Aseem Prakash articulates, "chemical accidents…outside the United States can strengthen public misgivings about the safety of industry's operations."[154] As one consultant for multinational firms operating in Asia stated, "For multinational companies such as Dow and DuPont, the ramifications of an accidental chemical spill because of poor handling or underdeveloped infrastructure can be disastrous. The negative publicity can negatively affect these companies' future plans *as well as other foreign companies looking to expand its* [sic] *business into China*."[155] In 2011, three of the 17 global capacity building projects funded by the RC leadership group were based in China and Hong Kong.[156] This reflected that China, alongside India, had become one of the "priority ICCA targets."[157]

Shared reputation: Reputation collectives vs certification clubs

In the early 2000s, faced with underdeveloped safety programs in China, which was a fast-growing chemical producer, leading chemical firms and ICCA advocated for more intensive RC adoption. Concerned that the ramifications of a chemical accident in China would spread to the entire industry, multinational companies regarded the diffusion of RC as a "preemptive measure to limit the negative consequences of laws or regulations prompted by an industrial accident or persistent lack of public trust."[158] At a Asia Pacific Chemical Industry Meeting, Patrick Ho, the president of Dow Chemical Pacific who would later serve as chair of AICM, urged the formation of a pan-Asian association that would help Asian companies address safety risks. "We need to respond to public concerns that Asian operations are held to lower standards," Ho said.[159]

Because it recognized that the entire industry shares reputational gains and losses, ICCA strove to incorporate all chemical firms in the RC program rather than maintain barriers around an exclusive group of high performers. When it comes to enforcing the excludability of RC membership benefits by clearly differentiating in-group firms from out-group firms, ICCA cannot operate like a certification club. Writing in the context of the Chemical Manufacturers' Association (CMA), the industry association for U.S. chemical firms,[160] Prakash captures this by articulating a hypothetical scenario in which an accident occurs in a RC nonadopter: "This accident imposes negative externalities (loss of goodwill) on other firms. This is because the stakeholders may not

[154] Prakash 2000, 202.
[155] Oey 1998. Emphasis ours.
[156] RCLG 2012.
[157] RCLG 2018.
[158] Lin 2001, 199.
[159] Westervelt 2000; cited in Lin 2001.
[160] It is now known as the American Chemistry Council.

differentiate CMA members who have adopted Responsible Care from those who have not and direct their wrath only at nonadopters."[161] In fact, the origins of the RC initiative, launched by the Canadian Chemical Producers' Association, date back to an accident that threatened the reputation of all chemical firms: the 1984 Bhopal disaster at the Union Carbide plant in India, which resulted in the deaths of thousands.[162]

Internal benchmarking vs. public naming and shaming

ICCA-China engagement also aligns with the expectations of the reputation collectives mechanism about name-and-shame tactics. In its annual RC status updates, CPCIF reports on industry averages of key performance indicators such as process safety event rates and injury rates per million man-hours, but it does not provide firm-specific data. Based on these reports, external stakeholders, such as the general public and advocacy organizations, cannot single out individual Chinese firms as poor performers.[163] This limited transparency is consistent with data sharing practices across the global RC regime, under which the ICCA collects data from national associations in aggregate form.[164]

There are some aspects of this case that point to the certification club mechanism at work. In November 2021, adhering to ICCA guidelines, CPCIF and AICM jointly registered a "China Responsible Care" trademark. To use this trademark in their brands, Chinese chemical firms must follow requirements on an annual basis, including performance indicator reporting as well as an annual assessment of their RC practices, which can be done in conjunction with the ISO 14001 certification process.[165] If this trademark becomes a tool for external stakeholders to praise in-club firms and criticize out-club firms, then this development would support the certification club mechanism. However, there is scant evidence that Chinese companies leverage this trademark in marketing and public relations. The CPCIF frames the trademark as a way to promote broader awareness about the program among firms, as opposed to a vehicle for firms to garner goodwill with consumers.[166] In sum, ICCA's RC promotion efforts in China aim to encourage laggard firms to share their shortcomings in an environment that protects them from negative outside publicity.

Assistance to weak links vs. exclusion of free riders

Another test of the reputation collective and certification club mechanisms is ICCA's approach to poor-performing Chinese firms that free-ride on RC's reputational benefits. Consider,

---

[161] Prakash 2000.
[162] Barnett and King 2008.
[163] CPCIF 2022; CPCIF 2021.
[164] In the cases when company-specific data is made available, national regulations mandate release of company-specific data. Conzelmann 2012.
[165] CPCIF 2022.
[166] PROCESS [流程工业] 2019.

for instance, the requirement that RC member firms report safety performance on indicators such as process safety incident rate. It is well-documented that, since CPCIF joined the RC leadership group in 2014, many of China's small and medium-sized chemical firms, which number around 30,000, have not met this requirement.[167] If ICCA denied RC membership benefits from disengaged Chinese firms, like Euro Chlor's attempts to prevent free-riding chlorine producers from accessing best practices manuals and other group goods, then this would partially validate the certification club mechanism.

On the contrary, instead of restricting the access of weak links to collective goods, ICCA has sought to assist Chinese firms that have not satisfied certain RC requirements. Rather than excluding these firms from accessing RC membership benefits, ICCA's 2018 Responsible Care Status Report acknowledged that the Chinese chemical industry faced "very particular challenges in performance reporting" and stated that it was "examining its options for a reporting approach that suits the reality of China's situation."[168] In 2018, ICCA and CPCIF published a three-year action plan to broaden RC adoption through piloting evaluation programs in chemical industry parks, popularizing knowledge of RC principles, and improving training and education for RC personnel in firms. In a speech at the 2019 China RC Promotion Conference, CPCIF president Shousheng Li emphasized the importance of this plan to help small and medium-sized enterprises with RC implementation, explicitly labeling these firms as "weak links" [薄弱环节].[169]

Alternative factors

Binding international agreements and top-down government directives cannot explain China's modest progress in chemical safety. In this domain, the global governance landscape is an "alphabet soup" of international agreements and initiatives, including the UN Environment Programme's Strategic Approach to International Chemicals Management policy framework, OECD's efforts to harmonize chemical standards, and UN agencies' nonbinding initiatives to adopt chemical safety cards.[170] In other words, at the level of intergovernmental instruments, Chinese regulators have limited levers to push through chemical safety reforms.

During this period, China has initiated and revised chemical safety regulations, but the implementation of these measures has been relatively poor. The 2014 national profile of China's chemicals management system, co-authored by Peking University researchers, identified large gaps in terms of the central government's policies and resources for chemical risk management. Specifically, the assessment concluded that the State Administration of Work Safety (SAWS), responsible for issuing licenses for hazardous chemical production, lacked institutional capacity and

[167] One report states, "Performance reporting by Chinese companies is not in line with the procedures specified by the International Council of Chemical Associations." Naidu 2019.
[168] RCLG 2018.
[169] PROCESS [流程工业] 2019. Since June 2020, ICCA has seconded an experienced chemical industry professional to CPCIF to assist with RC promotion and education. RCLG 2021.
[170] Sheoin 2014.

technical expertise.[171] According to a chemical regulation specialist from a Chinese consulting group, the lack of qualified local staff has also hindered enforcement of the amended Production Safety Law (2019), leading companies to seek out international companies for help with production safety.[172]

V. Conclusion

In this paper, we put forward and evaluate a novel theory of global private regulation in high-risk technologies. We theorize that, in industries with a collective safety reputation, international industry associations regulate safety among member firms by treating industry reputation as a communal good, protecting information on member performance from external stakeholders, and subsidizing laggard firms to keep them connected to the group. These reputation collectives diverge from the most prevalent model of international private regulation: certification clubs that maintain strict quality, safety, or environmental standards and deny membership benefits to firms that do not meet such standards. Tracing interactions between international industry associations and Chinese firms in three high-risk technological domains, the article's findings support the validity of the reputation collective mechanism.

This article contributes to a growing literature on voluntary self-regulation, which has challenged the assumption that global private governance is either futile or insubstantial. Previous scholarship has focused on clubs that grant membership to firms that uphold certification standards in safety, sustainability, human rights, etc.[173] However, as this article demonstrates, in certain settings when an accident's reputational effects spill over to the entire industry, the reputation collective mechanism provides a better account of how international industry associations endeavor to improve safety standards in emerging economies. If the design criteria of certification clubs — e.g., stringent membership criteria and credible enforcement procedures — is used to assess the effectiveness of voluntary initiatives in these high-risk technologies, then the resulting analysis may mislead more than it informs.

Our study of reputation collectives provides a basis for further exploration of the interdependencies between public and private regulation. Some evidence from the cases suggests that the effectiveness of reputation collectives is partially dependent on their relationship with international public agencies. It would be fruitful to explore, for example, whether the threat of strong ICAO regulations functions as an invisible force that encourages IATA to take action, or the extent to which WANO shares safety performance information with the IAEA.[174] Future work in this direction would build from existing research on public-private governance initiatives such as the

[171] Liu 2014.
[172] Naidu 2019.
[173] Potoski and Prakash 2005; Prakash and Potoski 2006.
[174] Interview with Cantelon, phone, 10/10/23.

United Nations Global Compact as well as the relationship between transnational private regimes and relevant domestic regulators.[175]

Finally, our findings also have implications for those that research and shape governance institutions in emerging technologies. For instance, over the past year, influential AI companies from multiple countries have agreed to a set of voluntary "Frontier AI Safety Commitments", which aim to reduce risks like powerful AI systems escaping human control.[176] Our paper suggests that an important variable for the design of these emerging initiatives is whether the AI industry develops a collective safety reputation. If it does, then the effectiveness of global private governance will rest on the features of reputation collectives: low entry requirements in pursuit of universal membership, avoidance of public naming-and-shaming, and reliance on socialization and peer-to-peer learning to improve the safety performance of laggards.[177]

[175] Thrall 2021; Allen 2023.
[176] Department for Science, Innovation & Technology (UK)
[177] Conzelmann 2012, 199-200.

References

Abbott, Kenneth W., and Duncan Snidal. "Taking Responsive Regulation Transnational: Strategies for International Organizations." *Regulation & Governance* 7, no. 1 (March 2013): 95–113. https://doi.org/10.1111/j.1748-5991.2012.01167.x.

Adalja, Aaron, Erik Lichtenberg, and Elina T. Page. "Collective Investment in a Common Pool Resource: Grower Associations and Food Safety Guidelines." *American Journal of Agricultural Economics* 105, no. 1 (2023): 144–73. https://doi.org/10.1111/ajae.12291.

Allen, Michael O. "Unbundling the State: Legal Development in an Era of Global, Private Governance." *International Organization* 77, no. 4 (April 2023): 754–88. https://doi.org/10.1017/S0020818323000218.

Aviation Week & Space Technology. "IATA's Aviation English Course Comes to China." *Aviation Week & Space Technology*, January 1, 1996. https://trid.trb.org/View/558995.

Ayoub, Ali, Andrej Stankovski, Wolfgang Kröger, and Didier Sornette. "The ETH Zurich Curated Nuclear Events Database: Layout, Event Classification, and Analysis of Contributing Factors." *Reliability Engineering & System Safety* 213 (September 1, 2021): 107781. https://doi.org/10.1016/j.ress.2021.107781.

Barkenbus, Jack. "Nuclear Power Safety and the Role of International Organization." *International Organization* 41, no. 3 (1987): 475–90.

Barnett, Arnold. "Aviation Safety: A Whole New World?" *Transportation Science* 54, no. 1 (January 2020): 84–96. https://doi.org/10.1287/trsc.2019.0937.

Barnett, Michael L. "Finding a Working Balance Between Competitive and Communal Strategies*." *Journal of Management Studies* 43, no. 8 (2006): 1753–73. https://doi.org/10.1111/j.1467-6486.2006.00661.x.

Barnett, Michael L., and Andrew A. King. "Good Fences Make Good Neighbors: A Longitudinal Analysis of an Industry Self-Regulatory Institution." *Academy of Management Journal* 51, no. 6 (December 2008): 1150–70. https://doi.org/10.5465/amj.2008.35732609.

Beach, Derek, and Rasmus Brun Pedersen. *Process-Tracing Methods: Foundations and Guidelines*. Ann Arbor: University of Michigan Press, 2013.

Berliner, Daniel, and Aseem Prakash. "Public Authority and Private Rules: How Domestic Regulatory Institutions Shape the Adoption of Global Private Regimes." *International Studies Quarterly* 58, no. 4 (2014): 793–803.

Braithwaite, John. "Responsive Regulation and Developing Economies." *World Development*, Part Special Issue (pp. 868–932). Making Global Corporate Self-Regulation Effective in Developing Countries, 34, no. 5 (May 1, 2006): 884–98. https://doi.org/10.1016/j.worlddev.2005.04.021.

Brumfield, Todd. "Evaluation of Safety Culture in WANO Pre-Startup Reviews." World Association of Nuclear Operators, 2012. https://gnssn.iaea.org/NSNI/SC/SCPoP/Papers%20prepared%20for%20meeting/Todd%20Brumfield_Evaluation%20of%20Safety%20Culture%20in%20WANO%20Pre-Startup%20Reviews_Paper.pdf.

Bunn, Matthew, and Olli Heinonen. "Preventing the Next Fukushima." *Science* 333, no. 6049 (September 16, 2011): 1580–81. https://doi.org/10.1126/science.1209668.

Büthe, Tim. "Private Regulation in the Global Economy: A (p) Review." *Business and Politics* 12, no. 3 (2010): 1–38.

Büthe, Tim, and Walter Mattli. *The New Global Rulers: The Privatization of Regulation in the World Economy*. Princeton University Press, 2011.

Butler, Declan. "Nuclear Industry Safety Body Takes on Lessons of Fukushima." *Nature*, November 21, 2011. https://doi.org/10.1038/nature.2011.9401.

CAEA. "14th Anniversary of Safe Operation at Qinshan Nuclear Power Plant [秦山核电站安全运行14周年]." China Atomic Energy Authority, 2006. https://www.caea.gov.cn/n6760338/n6760342/c6835483/content.html.

Cantelon, Philip. *Nuclear Safety Has No Borders: A History of The World Association of Nuclear Operators*. World Association of Nuclear Operators, 2016.

Carnegie, Allison, and Austin Carson. "The Disclosure Dilemma: Nuclear Intelligence and International Organizations." *American Journal of Political Science* 63, no. 2 (2019): 269–85. https://doi.org/10.1111/ajps.12426.

Chang, MJ. "Technologies for Improving Current and Future Light Water Reactor Operation and Maintenance: Development on the Basis of O&M Experiences - The WANO Perspective." International Atomic Energy Agency, 1999. https://inis.iaea.org/collection/NCLCollectionStore/_Public/31/053/31053009.pdf.

Chen, Chao, and Genserik Reniers. "Chemical Industry in China: The Current Status, Safety Problems, and Pathways for Future Sustainable Development." *Safety Science* 128 (August 1, 2020): 104741. https://doi.org/10.1016/j.ssci.2020.104741.

Chi, Cheryl S. F., and Ling Chen. "The Sources of Divergent Practices in China's Nuclear Power Sector." *Energy Policy*, Special Section: Frontiers of Sustainability, 48 (September 1, 2012): 348–57. https://doi.org/10.1016/j.enpol.2012.05.036.

China Civil Aviation Report. "IOSA Symposium Held in Urumqi." *China Civil Aviation Report*, 2012.

Chong, Liu. "After Fukushima: China's Nuclear Safety." *Survival* 55, no. 3 (July 1, 2013): 115–28. https://doi.org/10.1080/00396338.2013.802856.

Chu, May. "Horses for Courses: China's Accommodative Approach to Food Standard-Setting in Response to the Internationalization of Regulation." *Regulation & Governance* 14, no. 3 (2020): 514–30. https://doi.org/10.1111/rego.12228.

CNEA. *China Nuclear Energy Yearbook 2009 [中国核能年鉴 2009]*. Beijing: China Nuclear Energy Association, 2009.

———. *China Nuclear Energy Yearbook 2011 [中国核能年鉴 2011]*. Beijing: China Nuclear Energy Association, 2011.

———. *China Nuclear Energy Yearbook 2014 [中国核能年鉴 2014]*. Beijing: China Nuclear Energy Association, 2014.

———. *China Nuclear Energy Yearbook 2015 [中国核能年鉴 2015]*. Beijing: China Nuclear Energy Association, 2015.

———. *China Nuclear Energy Yearbook 2017 [中国核能年鉴 2017]*. Beijing: China Nuclear Energy Association, 2017.

———. *China Nuclear Energy Yearbook 2018 [中国核能年鉴 2018]*. Beijing: China Nuclear Energy Association, 2018.

———. *China Nuclear Energy Yearbook 2019 [中国核能年鉴 2019]*. Beijing: China Nuclear Energy Association, 2019.

Conzelmann, Thomas. "A Procedural Approach to the Design of Voluntary Clubs: Negotiating the Responsible Care Global Charter: Socio-Economic Review." *Socio-Economic Review* 10, no. 1 (January 2012): 193–214. https://doi.org/10.1093/ser/mwr031.

COSTIND. "Operational Assessment and Management Measures for Nuclear Power Plants (Trial) [核电厂运行评估管理办法(试行)]." Commission of Science, Technology, and Industry for National Defense, 2002. https://china.findlaw.cn/fagui/p_1/192004.html.

CPCIF. "China's Petroleum and Chemical Industry Responsible Care Report 2020." China Petroleum and Chemical Industry Federation, 2021.

———. "China's Petroleum and Chemical Industry Responsible Care Report 2021." China Petroleum and Chemical Industry Federation, 2022.

Ding, Yunfeng. "Joint Evaluation Activity of Daya Bay/Ling Ao Nuclear Power Station Officially Begins [大亚湾/岭澳核电站联合评估活动正式开始]." China Atomic Energy Authority, 2005. https://www.caea.gov.cn/n6760338/n6760342/c6835572/content.html.

Drexel, Bill, and Hannah Kelley. "China Is Flirting With AI Catastrophe." *Foreign Affairs*, May 30, 2023. https://www.foreignaffairs.com/china/china-flirting-ai-catastrophe.

Drezner, Daniel W., and Mimi Lu. "How Universal Are Club Standards? Emerging Markets and Volunteerism." In *Voluntary Programs: A Club Theory Perspective*, 181. MIT Press, 2009. https://books.google.com/books?hl=en&lr=&id=KKqWvYIzCywC&oi=fnd&pg=PA181&ots=ZbA3sJ5rYY&sig=I2Gq2P8rZ19Ste3hwuhHNj0Sbu4.

Eckered, T. "Progress in the Establishment of the World Association of Nuclear Operators (WANO)." Feedback of Operational Safety Experience from Nuclear Power Plants. International Atomic Energy Agency, 1989. https://inis.iaea.org/collection/NCLCollectionStore/_Public/21/043/21043660.pdf.

Eichengreen, Barry, and Guangtao Xia. "China and the SDR: Financial Liberalization through the Back Door." *The Quarterly Journal of Finance* 09, no. 03 (September 2019): 1950007. https://doi.org/10.1142/S2010139219500071.

Eilstrup-Sangiovanni, Mette. "Ordering Global Governance Complexes: The Evolution of the Governance Complex for International Civil Aviation." *The Review of International Organizations* 17, no. 2 (April 1, 2022): 293–322. https://doi.org/10.1007/s11558-020-09411-z.

Erickson, Andrew S. "China's Space Development History: A Comparison of the Rocket and Satellite Sectors." *Acta Astronautica* 103 (October 1, 2014): 142–67. https://doi.org/10.1016/j.actaastro.2014.06.023.

Fauchart, Emmanuelle, and Robin Cowan. "Weak Links and the Management of Reputational Interdependencies." *Strategic Management Journal* 35, no. 4 (2014): 532–49. https://doi.org/10.1002/smj.2122.

Findlay, Trevor. *Nuclear Energy and Global Governance: Ensuring Safety, Security and Non-Proliferation*. Routledge, 2010. https://books.google.com/books?hl=en&lr=&id=PAysAgAAQBAJ&oi=fnd&pg=PP1&dq=nuclear+energy+and+global+governance+ensuring+safety+security+and+non-proliferation+findlay&ots=FOeSE3HPMc&sig=omQzi7cy8NgEBTPws1LXa7yKNzo.

Gronlund, Lisbeth, David Lochbaum, and Edwin Lyman. "Nuclear Power in a Warming World: Assessing the Risks, Addressing the Challenges." Union of Concerned Scientists, December 2007. http://large.stanford.edu/courses/2011/ph241/sharif1/docs/nuclear-power-in-a-warming-world.pdf.

Gu, Xinping. "Qinshan II Nuclear Power Plant Receives WANO Peer Review Follow-up Visit [秦山二核接受WANO同行评估回访]." China Atomic Energy Authority, 2005. https://www.caea.gov.cn/n6760338/n6760342/c6835700/content.html.

———. “Second Meeting of the Nuclear Power Plant Operation Evaluation Committee Convenes [核电厂运行评估委员会第二次会议召开].” China Atomic Energy Authority, 2004. https://www.caea.gov.cn/n6760338/n6760342/c6831813/content.html.

Gunningham, Neil, and Darren Sinclair. *Leaders and Laggards: Next-Generation Environmental Regulation*. London: Routledge, 2017. https://doi.org/10.4324/9781351282000.

He, Peng, and Ruishan Sun. “Trends and Characteristics of Incidents in China Civil Aviation: 1994–2020.” *Transportation Research Record* 2677, no. 5 (May 1, 2023): 420–31. https://doi.org/10.1177/03611981221131314.

Hounsell, Geoff. “IOSA - IATA Operational Safety Audit Programme.” Presented at the ICAO, World Bank Development Forum Maximizing Civil Aviation’s Contribution to Global Development Aviation Development Focus on Asia/Pacific Safe, Secure and Sustainable Air Transport, 2008. https://www.icao.int/Meetings/AMC/MA/Forum08_2008/hounsell.pdf.

Huang, Qing. “Qinshan Nuclear Power Plant: Rising in Global Rankings [秦山核电: 全球排名节节高].” *Sina News*, 2006. https://news.sina.com.cn/c/2006-12-11/090010735027s.shtml.

IAEA. “IAEA Mission Says China’s Nuclear Regulator Effective; Should Continue to Enhance Safety Programme.” International Atomic Energy Agency, 2016. https://www.iaea.org/newscenter/pressreleases/iaea-mission-says-chinas-nuclear-regulator-effective-should-continue-to-enhance-safety-programme.

———. “Integrated Regulatory Review Service (IRRS) Report to the Government of the People’s Republic of China.” International Atomic Energy Agency, 2010. https://www.iaea.org/sites/default/files/documents/review-missions/irrs_mission_to_china_jul_2010_2.pdf.

———. “Report of the Technical Committee Meeting 1997 Annual Workshop on ASSET Experience and Feedback,” October 1, 1997. https://www.osti.gov/etdeweb/biblio/575600.

———. “Ten Years After Chernobyl: What Do We Really Know?” International Atomic Energy Agency, 1997.

IATA. “IATA Annual Review 2015,” June 2015. https://www.utikad.org.tr/images/BilgiBankasi/iataannualreview2015-4602.pdf.

———. “IATA Annual Safety Report (2005),” April 2006. https://www.iata.org/contentassets/4d18cb077c5e419b8a888d387a50c638/iata-safety-report-2005.pdf.

———. “IOSA — THE IATA OPERATIONAL SAFETY AUDIT PROGRAMME.” Montreal: Directors General of Civil Aviation Conference on a Global Strategy for Aviation Safety, March 6, 2006. https://www.icao.int/Meetings/AMC/MA/Directors%20General%20of%20Civil%20Aviation%20Conference%20on%20a%20Global%20Strategy%20for%20Aviation%20Safety%20(DGCA-06)/dgca_06_ip_12_e.pdf.

———. “Safety Trend Evaluation, Analysis and Data Exchange System FAQ,” n.d. https://www.iata.org/contentassets/7686e6e630ca406f9c7dab74361f8854/steades-faq.pdf.

Jing, Liu, and Michael Faure. “Compensating Nuclear Damage in China.” *Washington University Global Studies Law Review* 11, no. 4 (January 1, 2012): 781–816.

Johnston, Alastair Iain. *Social States*. Princeton, NJ: Princeton University Press, 2007. https://press.princeton.edu/books/paperback/9780691134536/social-states.

Kadak, Andrew C. “Nuclear Power: ‘Made in China.’” *The Brown Journal of World Affairs* 13, no. 1 (2006): 77–90.

Kan, Karoline. "China's Latest Chemical Plant Explosion Was Avoidable." *Dialogue Earth* (blog), March 26, 2019. https://dialogue.earth/en/pollution/11159-china-s-latest-chemical-plant-explosion-was-avoidable/.

Kelley, Judith G., and Beth A. Simmons. "Politics by Number: Indicators as Social Pressure in International Relations." *American Journal of Political Science* 59, no. 1 (2015): 55–70. https://doi.org/10.1111/ajps.12119.

King, Amy, and M. V. Ramana. "The China Syndrome? Nuclear Power Growth and Safety After Fukushima." *Asian Perspective* 39, no. 4 (2015): 607–36.

King, Andrew A., and Michael J. Lenox. "Industry Self-Regulation without Sanctions: The Chemical Industry's Responsible Care Program." *The Academy of Management Journal* 43, no. 4 (2000): 698–716. https://doi.org/10.2307/1556362.

Lau, Jack. "China Turned around Its Air Safety Record, but How Safe Is It?" *South China Morning Post*, April 2, 2022, sec. News. https://www.scmp.com/news/china/politics/article/3172778/china-turned-around-its-air-safety-record-how-safe-it.

Lin, Kun-Chin. "Finding the Right Chemistry: The U.S. Chemical Industry in Asia: Business & Politics." *Business & Politics* 3, no. 2 (August 2001): 185–202. https://doi.org/10.2202/1469-3569.1024.

Linshi, Jack. "Why Airlines Don't Talk About Safety In Their Ads." *TIME* (blog), January 20, 2015. https://time.com/3669161/airline-ads-safety/.

Liu, Jianguo. "National Profile of Chemicals Management in China." United Nations Institute of Training and Research, December 2014. https://cwm.unitar.org/national-profiles/nphomepage/np3_region.aspx#asia.

Mac Sheoin, Tomás. "Controlling Chemical Hazards: Global Governance, National Regulation?" *Social Justice* 41, no. 1/2 (135-136) (2014): 101–24.

McLean, Elena V, and Taehee Whang. "Do Sanctions Spell Disaster? Economic Sanctions, Political Institutions, and Technological Safety." *European Journal of International Relations* 26, no. 3 (September 1, 2020): 767–92. https://doi.org/10.1177/1354066119887422.

MEE. "Nuclear Safety Law of the People's Republic of China [中华人民共和国核安全法]." Ministry of Ecology and Environment, 2017. https://www.mee.gov.cn/ywgz/fgbz/fl/202110/t20211028_958223.shtml.

Mills, Russell W. "The Interaction of Private and Public Regulatory Governance: The Case of Association-Led Voluntary Aviation Safety Programs*." *Policy and Society* 35, no. 1 (March 1, 2016): 43–55. https://doi.org/10.1016/j.polsoc.2015.12.002.

Montjoie, Michel. "Treaty Implementation Applied to Conventions on Nuclear Safety." *Nuclear Law Bulletin* 96 (2015): 9–34.

Naidu, Rashmi. "China Makes Slow Progress on Safety." *Chemistry World*, June 11, 2019. https://www.chemistryworld.com/news/china-makes-slow-progress-on-safety/3010599.article.

NEI. "WANO Elects New Executives." Nuclear Engineering International, 2010. https://www.neimagazine.com/news/wano-elects-new-executives/.

NNSA. "The First National Report Under the Convention on Nuclear Safety of the People's Republic of China." National Nuclear Safety Administration, 1998. https://nnsa.mee.gov.cn/english/resources/national/201805/P020180524576894528246.pdf.

———. "The Third National Report Under the Convention on Nuclear Safety of the People's Republic of China." National Nuclear Safety Administration, 2004.

https://nnsa.mee.gov.cn/english/resources/national/201805/P020180524579155130280.pdf.
NRC. "Cable Regarding Visit of Commissioner Jeffrey S. Merrifield." Nuclear Regulatory Commission, 2001. https://www.nrc.gov/docs/ML0310/ML031040436.pdf.
Nyirubutama, Jean-Paul. "Industry Contribution to Aviation Safety Improvement: RwandAir IOSA Process and IATA Support." Presented at the AFI Aviation Safety Symposium, 2014. https://www.icao.int/Meetings/AFIsymposium2014/Documents/Session%206%20-%20RwandAir%20talking%20points%20-%20AFI%20ICAO%20Aviation%20Safety%20Symposium%20.pdf.
O'Brien, Mike. "IOSA - the IATA Operational Safety Audit Programme," 2004.
Oey, Patricia. "Responsible Care in Asia Advances," February 16, 1998. https://www.proquest.com/docview/194722681?sourcetype=Trade%20Journals.
Osnos, Evan. "China's Nuclear Binge." *The New Yorker*, March 14, 2011. https://www.newyorker.com/news/evan-osnos/chinas-nuclear-binge.
Ostrom, Elinor. *Governing the Commons: The Evolution of Institutions for Collective Action*. Cambridge university press, 1990. https://books.google.com/books?hl=en&lr=&id=4xg6oUobMz4C&oi=fnd&pg=PR11&dq=ostrom+governing+the+commons+1990&ots=aQ4wBImGXe&sig=EnI3ePRSWmIWB2s2CqzaRzdRh60.
Pasztor, Andy. "How China Turned Around A Dismal Air-Safety Record." *Wall Street Journal*, October 10, 2007, sec. News. https://www.wsj.com/articles/SB119198005864354292.
Perrow, Charles. *Normal Accidents: Living with High Risk Technologies*. New York: Basic Books, 1984.
Potoski, Matthew, and Aseem Prakash. "Green Clubs and Voluntary Governance: ISO 14001 and Firms' Regulatory Compliance." *American Journal of Political Science* 49, no. 2 (2005): 235–48. https://doi.org/10.1111/j.0092-5853.2005.00120.x.
Prakash, Aseem. "Responsible Care: An Assessment." *Business & Society* 39, no. 2 (June 1, 2000): 183–209. https://doi.org/10.1177/000765030003900204.
Prakash, Aseem, and Matthew Potoski. *The Voluntary Environmentalists: Green Clubs, ISO 14001, and Voluntary Environmental Regulations*. 1st edition. Cambridge, UK ; New York: Cambridge University Press, 2006.
PROCESS[流程工业]. "Accidents Continue to Occur. How Can the Safety Level of the Chemical Industry Be Improved? [事故不断，事故不断，化工行业安全水平如何提升?]." *The Paper [澎湃新闻]*, May 10, 2019. https://chem.jgvogel.cn/c/2019-05-10/513709.shtml.
Prozesky, Peter. "WANO 30 Years On." Nuclear Engineering International, 2020. https://www.neimagazine.com/analysis/wano-30-years-on-7790175/.
RCLG. "2018 ICCA Responsible Care Leadership Group Status Report." ICCA, December 2018.
———. "2021 ICCA Responsible Care Leadership Group Status Report." ICCA, December 2021.
———. "ICCA Responsible Care Progress Report (2002-2012)." ICCA, 2012.
Rees, Joseph. "Development of Communitarian Regulation in the Chemical Industry." *Law & Policy* 19, no. 4 (October 1997): 477–528. https://doi.org/10.1111/1467-9930.00036.
Rees, Joseph V. *Hostages of Each Other: The Transformation of Nuclear Safety Since Three Mile Island*. University of Chicago Press, 1994.
Reuters. "China Nuclear Safety Chief Warns of Over-Rapid Growth." *Reuters*, April 20, 2009, sec. Environment. https://www.reuters.com/article/business/environment/china-nuclear-safety-chief-warns-of-over-rapid-growth-idUSTRE53J1T6/.

Reynolds, Nicholas. "Iata Guides Mainland to Safe Landing." *South China Morning Post*, December 13, 1995. https://www.scmp.com/article/142623/iata-guides-mainland-safe-landing.
Ronit, Karsten. *The Governance of Global Industry Associations: The Role of Micro-Politics*. Edward Elgar Publishing, 2022.
Sabec, Lindsey. "FAA Approves IATA's Operational Safety Audit (IOSA) Program: A Historical Review and Future Implications for the Airline Industry." *Transportation Law Journal* 32, no. 1 (2004). https://trid.trb.org/View/759040.
Scharre, Paul. "Killer Apps." *Foreign Affairs*, April 16, 2019. https://www.foreignaffairs.com/articles/2019-04-16/killer-apps.
Schofield, Adrian. "Twenty-One Carriers Lose Membership Due To Safety Audit, IATA Says | Aviation Week Network." *Aviation Week* (blog), April 2, 2009. https://aviationweek.com/twenty-one-carriers-lose-membership-due-safety-audit-iata-says?check_logged_in=1.
SCMP Reporter. "Iata Welcomes Fourth Chinese Airline to Group." *South China Morning Post*, May 7, 1996. https://www.scmp.com/article/158939/iata-welcomes-fourth-chinese-airline-group.
Shughuart, Rusty E. "China's Perspectives on Air Traffic Managmeent." Institute for National Security Studies, January 10, 1998. https://apps.dtic.mil/sti/tr/pdf/ADA367195.pdf.
Spar, Debora L. *The Cooperative Edge: The Internal Politics of International Cartels*. Cornell University Press, 1994.
Suttmeier, Richard P. "The 'Sixth Modernization'?: China, Safety, and the Management of Risks." *Asia Policy*, no. 6 (2008): 129–46.
Thrall, Calvin. "Public-Private Governance Initiatives and Corporate Responses to Stakeholder Complaints." *International Organization* 75, no. 3 (2021): 803–36.
Tsingou, Eleni. "Club Governance and the Making of Global Financial Rules." *Review of International Political Economy* 22, no. 2 (2015): 225–56.
Utting, Peter. "Corporate Responsibility and Labour Issues in China: Reflections on a Beijing Conference." *The Journal of Corporate Citizenship*, no. 10 (2003): 21–27.
vasundhara. "Safety in Numbers." *Airport Technology* (blog), February 17, 2009. https://www.airport-technology.com/features/feature49964/.
Wang, Shuai, Mengyue Xia, Xing Shi, Bojun Hou, and Shu Lu. "China's Distinctive Civil–Military Integration Policy and Firm Innovation." *Science and Public Policy*, April 30, 2024, scae013. https://doi.org/10.1093/scipol/scae013.
WANO. "About WANO Membership." World Association of Nuclear Operators, 2024. https://www.wano.info/members/about-wano-membership.
———. "WANO Completes the Registration of Its New Shanghai Branch Office." World Association of Nuclear Operators, 2020. https://www.wano.info/news-events/press-releases/wano-completes-the-registration-of-its-new-shangha.
———. "WANO Performance Indicators 2019." World Association of Nuclear Operators, 2019. https://www.wano.info/getmedia/c77f6990-37c8-4550-bb1f-2cd4b69829a4/2004-WANO-Performance-Indicator-Electronic-Document-6pp.pdf.aspx.
Westervelt, Robert. "Assessing Post-Crisis Asia: Chemical Week." *Chemical Week* 162, no. 12 (March 22, 2000): 38–39.
WNN. "WANO Sees Harmonisation as a Key Goal for Nuclear Operators." World Nuclear News, 2017. https://www.world-nuclear-news.org/Articles/WANO-sees-harmonisation-as-a-key-goal-for-nuclear.
Wright, Tim. "The Political Economy of China's Dramatically Improved Coal Safety Record." *The China Quarterly* 249 (March 2022): 91–113. https://doi.org/10.1017/S0305741021000941.

Xu, Yi-chong. "The Struggle for Safe Nuclear Expansion in China." *Energy Policy* 73 (October 1, 2014): 21–29. https://doi.org/10.1016/j.enpol.2014.05.045.

Yasuda, John K. "Regulatory State Building under Authoritarianism: Bureaucratic Competition, Global Embeddedness, and Regulatory Authority in China." *Comparative Politics* 54, no. 1 (2021): 123–2.

Yasuda, John Kojiro. "Explaining Policy Failure in China." *The China Quarterly* 257 (March 2024): 3–19. https://doi.org/10.1017/S0305741023000711.

Yi-chong, X. *The Politics of Nuclear Energy in China*. Springer, 2010.

Yu, Qian. "Exploring Huaneng Shidao Bay Nuclear Power Base: Showcasing Brand Appeal and Welcoming New Development Opportunities [走进华能石岛湾核电基地: 展现品牌魅力, 迎来发展新空间]." State-owned Assets Supervision and Administration Commission, 2024. http://www.sasac.gov.cn/n4470048/n29955503/n30549425/n30549435/c30714448/content.html.

Zhang Jianxin, Yu Haitian, and Xiong Jianbo. "Strategic Analysis on Implementing Safety Culture in Civil Aviation Enterprise [民航运输企业实施安全文化战略的分析]." *China Safety Science Journal [中国安全科学学报]* 16, no. 6 (June 20, 2006): 79.

Zhang, Yinling, and Lingling He. "秦山核电站再创连续运行新记录." Zhejiang Online News, 2003. https://zjnews.zjol.com.cn/system/2003/07/02/001724100.shtml.

Zhou, Keping, Luwei Xiao, Yun Lin, Danling Yuan, and Jiachuang Wang. "A Statistical Analysis of Hazardous Chemical Fatalities (HCFs) in China between 2015 and 2021." *Sustainability* 14, no. 4 (January 2022): 2435. https://doi.org/10.3390/su14042435.

Zwetsloot, Remco, Helen Toner, and Jeffrey Ding. "Beyond the AI Arms Race." *Foreign Affairs*, November 16, 2018. https://www.foreignaffairs.com/reviews/review-essay/2018-11-16/beyond-ai-arms-race.