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How Do Countries with Identical Hazards End Up with Different Industrial Safety Regulations?

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In a globalized world, industrial risks linked to the hazard potential of physic-chemical and/or biological processes and phenomena transcend borders, yet there are disparities in regulations leading to differences in risk management practices and hence protection worldwide. This article examines the factors that can explain and influence the diversity of regulations governing industrial and natural hazards in different countries. The analysis shows that differences can be explained by three main factors: (1) political systems, (2) economic priorities and (3) cultural and historical legacies. These disparities raise questions about risk management in multinational companies and international cooperation. While total harmonization seems both impossible and undesirable, the study recommends a middle way of strengthened and flexible international cooperation, respecting local specificities while promoting the sharing of expertise.

* 1. Introduction

Hazard is defined as the intrinsic property or capacity of an element (substance, equipment, work method, etc.) to potentially cause harm; risk, on the other hand, represents the probability of harm occurring because of exposure to a hazard, combined with the potential severity of that harm (Aven, 2016; Le Breton, 2017). It is therefore possible concretization of the hazard in a specific context, considering the probability of occurrence and the severity of the consequences. In an increasingly standardized world (Dudouet, *et al.*, 2005), hazards, as we know them, ignore borders. Yet, when faced with similar hazards, the regulations adopted by different countries vary significantly. This was illustrated, for example, during the COVID-19 pandemic, in response to which nations showed considerable differences in terms of containment, screening strategy and vaccination policy. This diversity of regulations, despite identical dangers, raises questions about global risk and crisis management. In a world where production organizations transcend national boundaries, as do certain potential hazards, the disparity or even divergence of regulations can lead to inequalities in terms of employee and population protection, and to problems of cooperation and interoperability. Industrial safety regulations offer a particularly relevant illustration of these issues. In sectors where hazardous substances and complex processes are involved, risk management is shaped by distinct national and regional legislative frameworks. In Europe, for instance, the Seveso Directive provides a robust legal structure for controlling major industrial risks. Originating from the 1976 Seveso disaster in Italy, this directive has evolved into its current form, Seveso III (2012/18/EU), which imposes strict obligations on high-risk industrial sites in terms of hazard identification, prevention measures, emergency preparedness, and transparency towards the public. While the European framework prioritizes a proactive and precautionary approach, other regions of the world rely on different regulatory philosophies, ranging from performance-based regulations to more prescriptive legal frameworks. Beyond Seveso, complementary regulatory frameworks, including the REACH regulation for chemical substances and the ATEX directives on explosive atmospheres, further illustrate how risk governance varies depending on geopolitical, economic, and cultural contexts. In this article, we propose an examination of the cultural, economic, political and historical factors that influence the construction of risk management policies in different national contexts. This reflection will be developed in three stages: first, the influences of political and institutional factors in thinking about these texts (part 2), then the impact of socio-economic determinants in the drafting of risk regulations (part 3), and finally the role of cultural and historical aspects in risk perception (part 4).

* 1. Political and institutional factors
     1. Political systems and institutional structures

First, we propose to examine the political and institutional influences that play a role in shaping risk management policies. The difference between democratic and authoritarian regimes plays a key role in how countries approach regulation in the face of common industrial hazards. In democratic regimes, decision-making is often characterized by a multitude of actors, including government representatives, non-governmental organizations, the media, and above all the public, through consultation and debate processes. In Europe, for example, the drafting of the REACH (Registration, Evaluation, Authorization, and Restriction of Chemicals) regulation involved years of public discussion, impact studies, and negotiations between member states, industry, and civil society (ECHA, 2007). This process, though long and complex, results in regulations that reflect a broad social consensus but can also be more restrictive due to public pressure for high levels of health and environmental protection. A similar approach is observed in the Seveso Directive, which has evolved through successive iterations (Seveso I in 1982, Seveso II in 1996, and Seveso III in 2012) to integrate new knowledge on industrial risks and lessons from past disasters (Nicola et al., 2018). The directive imposes strict risk assessment, accident prevention, and emergency response obligations on industrial operators, demonstrating the European Union’s precautionary principle in action. In contrast, other regulatory environments operate under different paradigms. In the United States, for instance, industrial safety regulations are shaped by agencies such as the Occupational Safety and Health Administration (OSHA) and the Environmental Protection Agency (EPA), which emphasize performance-based standards and corporate accountability (Hopkins, 2019). The regulatory approach is often influenced by economic considerations and industry lobbying, leading to variations in the stringency of safety requirements across different sectors and states. In authoritarian regimes, decision-making is largely centralized and dominated by a small group of leaders, often without meaningful public consultation. Industrial safety regulations in these contexts may prioritize economic growth and industrial expansion over risk prevention, leading to reactive rather than preventive regulatory frameworks (Rothstein et al., 2017). While some countries have strengthened their regulatory oversight following major industrial disasters such as China after the 2015 Tianjin explosions many still struggle with enforcement, transparency, and compliance due to weaker institutional controls and limited public scrutiny (Zhao et al., 2020). This difference in decision-making explains why, even when faced with identical hazards, democratic and authoritarian regimes can result in radically different industrial regulations.

In addition to the political regime, institutional structures at different scales influence risk regulations to a greater or lesser extent. Structural institutions are therefore key players to study, as they wield varying powers of action at different scales affecting the determination and application of risk-related regulatory policies. Differences in the way rules are designed and applied, depending on the institutions involved, go a long way towards explaining why countries facing the same industrial hazards may adopt different regulations. Rules are not simply universal prescriptions, but contextual social constructs, shaped by specific practices, traditions and values (Cometti, 2011). Thus, the same rule may be interpreted and implemented differently depending on the local or national context. For example, an environmental regulation may be strictly enforced in a country where environmental protection is a dominant societal value, while it might be more flexible in another where economic priorities prevail. Sociology and anthropology have helped to show how institutions, whether local, regional, national or international in scope, influence the way we think about the world. Failing to think "for themselves", institutions play a role in our classifications and categorizations, structure collective memory (what is remembered, or forgotten) and ultimately impact the most profound decisions, including in areas such as justice, life and death (Douglas, 1986). The weight of institutions thus influences the design of risk regulations. Local institutions, for example, may favor regulations that meet the immediate needs of their population, while international institutions such as the UN or NATO seek to harmonize standards, but must deal with cultural and political differences. This institutional diversity therefore leads to variations in risk regulation, even when the hazards are identical, as each institutional level brings its own interpretation, priorities and classification methods, hierarchy of values and management approaches.

* + 1. Relationship between national and international priorities

The influence of political priorities on industrial risk regulations also varies considerably at regional, national and international levels, helping to explain why countries facing the same hazards adopt different approaches to risk management. Thus, a country driven by environmental and public health concerns will tend to impose stricter standards than countries where economic or industrial priorities take precedence over safety requirements. For example, regulations on industrial emissions or chemical production, studied comparatively, are more restrictive in France than in Germany or Spain because authorities may prioritize industrial competitiveness (Dubertret, et al., 2016). Finally, international rules are often the result of compromises between divergent national interests (Grosbon, 2022). The 1993 International Convention for the Prevention of Major Industrial Accidents, drawn up by the International Labour Organization, aims to harmonize industrial safety regulations between developing and developed countries. However, the divergent political priorities of these nations the former seeking to protect their economic growth, the latter emphasizing high safety standards contribute to heterogeneous regulations. Developing countries may perceive strict safety standards as obstacles to their economic growth, due to high compliance costs and lack of technical resources. For example, studies have shown that standards can act as barriers to exports for developing countries, due to high compliance costs and lack of technical resources (Timmis, 2017).

We have attempted to establish, at a high level, the influences that political and institutional structures can exert in decision-making concerning risk regulations. We will now consider the various socio-economic factors that can have a significant impact on the effectiveness of regulations and thus influence risk management choices.

* 1. Socio-economic determinants
     1. Economic development level

Socio-economic determinants can play a key role in a country's inclination to introduce safety regulations. The financial capacity of countries to implement risk prevention and management measures is also a factor to be considered, explaining why countries faced with the same hazards adopt different regulations. Petit (2023) illustrates that the consequences of disasters are largely determined by human choices (economic resources, type of infrastructure...). Developed countries with greater financial resources can afford to implement strict regulations, sophisticated early warning systems and invest in resilient infrastructures. Following the 2011 earthquake, Japan significantly strengthened its nuclear safety standards and invested heavily in disaster-prevention technologies. For example, the Nuclear Regulation Authority (NRA) was established in 2012 as an independent body, revising nuclear regulatory standards based on lessons learned from the Fukushima accident. In contrast, many developing countries with limited or very limited resources restrict the adoption of such stringent regulations, even though the hazards they may face are similar. These countries prefer less costly measures or delay the implementation of stricter standards. example, hazardous industries and undesirable technologies are often relocated to developing countries. Indeed, it is advantageous to transfer an entire production unit to a country where risk regulations are less restrictive and, therefore, less costly to apply (Jeyaratnam, 2000). This disparity in financial capacity leads to a variety of regulatory approaches, reflecting not only national priorities, but also local economic realities and opportunities

* + 1. Impact of socio-economic disparities

Internal inequalities within countries also play a role in the effectiveness of risk regulations, contributing to divergences in the way these countries address similar hazards. Poorer populations, often concentrated in high-risk industrial zones, often have fewer means of complying with regulations or asserting their rights in the event of non-compliance with safety standards. In some industrial regions, for example, communities living near chemical plants or hazardous production sites are often the most exposed to risk, but rarely have the resources to demand better enforcement of regulations or to protect themselves effectively. This was notably the case in the Ulsan/Onsan industrial complex in the Republic of Korea, where the concentration of industrial investment in the area led to a rapid influx of population with little regard for the impact of such demographics in terms of risk. In 1962, the area around the plant was populated by 100,000 people; within 30 years, it had grown to 600,000. In 1962, 500 households lived within the perimeter of the industrial complex; by 1992, there were 6,000. Residents complained of a wide range of health problems attributable to industrial pollution (WHO, 1992). These inequalities make regulations less effective, as local authorities may lack the political will or capacity to impose strict standards in economically marginalized areas. In addition, children and the elderly, particularly vulnerable populations, can sometimes be overlooked in the development and application of regulations. Around the world, for example, air pollution standards vary from country to country, and do not always consider the specific impact on the health of children and the elderly, who are more sensitive to contaminants (UN, 2021). This neglect can lead to less protective regulations for these groups, even though the dangers are well known. Thus, internal inequalities not only affect the design of safety regulations but can also lead to disparities in their actual implementation. In addition to financial resources, skilled human resources such as specialized experts are needed to improve risk management. Access to qualified professionals and cutting-edge technologies, for example, are also important considerations. During the 2004 earthquake and tsunami in the Indian Ocean, inequalities in access to monitoring and early warning technologies highlighted countries' capacities to manage natural hazards. Countries such as Indonesia and Sri Lanka, which lacked sophisticated technological infrastructures and sufficient expertise, were hard hit by this disaster, with considerable human and material losses. By way of comparison, a country like Japan, which had long invested in advanced seismic detection and risk management systems, was better prepared to respond to this type of disaster (a preparedness reflected in stricter regulations and resilient infrastructures). Nations with advanced technological resources and specialized expertise are therefore able to develop more rigorous safety standards and more sophisticated risk management strategies. Less developed countries, on the other hand, lacking equivalent access to these resources, may be forced to adopt less stringent regulations or rely on more reactive rather than preventive approaches. Socio-economic factors therefore help to explain why, despite common hazards, risk regulations vary considerably from one country to another.

A final category of determinants, probably the most significant, remains to be presented: traditions, beliefs and past experiences with disasters, which make up what we call cultural perceptions of risk.

* 1. Cultural and historical aspects
     1. Traditions and beliefs

In this final section, we present the cultural and historical dimensions constituting a legacy that influences the development of industrial risk management policies. Lannoy (2013) uses the term risk acceptability to describe the way in which a society perceives, accepts or rejects risks, with a direct influence on the norms and rules that will be established by that society. For example, in some European countries, where the precautionary principle is strongly entrenched, regulations can be very strict, reflecting a low tolerance of risk. Conversely, in cultures where risk is perceived as an integral part of economic life, or as an inevitability, regulations may be more flexible, allowing greater risk-taking (by developers in their construction, by industrialists in their activities, by drivers on the roads, etc.). A comparative analysis of safety principles (Le Trung, 2003) shows that three risk assessment approaches also yield different results in terms of risk acceptability in each country. A comparison of the GAME (Globally At Least Equivalent), MEM (Minimum Endogenous Mortality) and ALARP (As Low As Reasonably Practicable) methods, illustrates the variability of these principles according to the specificities of each nation. In Anglo-Saxon countries, the ALARP principle, which advocates reducing risks to a level deemed reasonably acceptable, is often favored, illustrating an approach in which economic efficiency is considered in risk assessment. On the other hand, other countries such as Germany may prefer principles such as the MEM method, which requires exogenous mortality (accidents) to be lower than endogenous mortality (natural death), reflecting a more statistical approach to risk. The relationship to the value of human life (Boiteux and Baumstark, 2001) also acknowledges that cultural perceptions influence the way countries value human life in their risk management policies. In the USA, the monetary valuation of human life in cost-benefit analyses leads to different decisions from those taken in countries where human life is considered invaluable, and where regulations seek to minimize the number of human losses whatever the costs (in theory at least). All these considerations tend to show that cultural differences shape the relationship to safety in different countries, reflecting the values and priorities specific to each society and influencing risk regulations. The beliefs and traditions that underpin social and political values and priorities are not arbitrary choices, however, but depend on the history of societies. Thus, past disasters shape current and future responses.

* + 1. The weight of historical catastrophes

The history of industrial and natural disasters has shaped risk management policies and priorities around the world. Past experiences play a decisive role in the way countries design and implement their regulations and governance. These events influence not only technical and legal standards, but also public perception of risk and the political will to adopt preventive measures. Each society, depending on its specific history with this type of event, then develops a unique approach to risk management, adapts to its lessons from the past, and applies it on a different scale. Firstly, major industrial disasters have often led to drastic revisions of regulations at international level. For example, the 2011 Fukushima nuclear disaster in Japan had global repercussions, profoundly altering energy policies and nuclear safety standards. In response, Japan revised its safety standards by imposing stricter requirements for nuclear power plants, while some countries, such as Germany, decided to phase out nuclear power by accelerating their transition to renewable energies. Conversely, in other regions where nuclear power remains a major pillar, changes have been more gradual, focusing mainly on improving existing infrastructures. Countries with prior experience of industrial disasters have generally reacted more quickly, adopting rigorous measures to avoid similar incidents. The role of disasters in shaping risk management policies can also be seen on a continental scale. Take, for example, the Seveso accident in Italy in 1976, where a leak of toxic herbicide contaminated a vast area and subsequently triggered an unprecedented awareness in Europe of the risks associated with hazardous industrial activities. This tragedy gave rise to the Seveso Directive, a strict European regulatory framework for the prevention of major accidents involving hazardous substances. This directive requires EU member states to identify sites at risk and implement appropriate safety measures, while guaranteeing full transparency with local populations about these hazards. The impact of Seveso has been continental, even if other parts of the world have adopted different approaches based on their own experiences. Finally, experience with industrial accidents also influences public perception of risk, which in turn can shape national regulations. The explosion at the AZF factory in France in 2001 led to a major reappraisal of regulations governing industries in urban areas. This event not only tightened safety requirements for industrial facilities, but also heightened the French public's awareness of the risks of hazardous industries located close to residential areas. In response, the French authorities tightened controls and required more stringent risk reduction plans for industrial facilities, particularly those located close to housing, with the creation of “Plans de Prévention des Risques Technologiques” (PPRT). This regulatory responsiveness contrasts with countries where similar events have not led to such drastic changes, often due to less public pressure or priority given to other economic aspects. It is important to point out that the lack of experience with major disasters may also help explain why some countries maintain less stringent regulations. Prior to Hurricane Katrina in 2005, the United States had not put in place such stringent regulations for flood protection in certain at-risk areas. Katrina revealed shortcomings in the country's risk management in the face of this natural disaster, and thus led to a review of hurricane and flood protection infrastructures. This kind of revision in response to such events highlights a reactive rather than proactive regulatory dynamic, which often depends on the severity of the event and its impact on society. This partly explains the discrepancies between countries facing similar hazards, as these events have a profound impact on societies and their governments, prompting them almost systematically to reassess, reinforce or sometimes completely rethink their risk management policies.

* 1. Discussion

Let's remember that a hazard represents the potential damage caused by a physic-chemical-biological phenomenon, while a risk represents the probability of damage occurring following exposure to a hazard. We could say that danger is natural, risk is human, social (Beck, 1986). Our initial question, "Why do countries facing the same hazards establish different risk management regulations?" contained, in the definition of the terms, its answer: because these countries have different histories, different cultures, different representations and therefore, they construct different relationships to risks. At the end of a structured inventory of the factors that determine these differences, and a reflection on their effects, it appears that total harmonization of risk regulations is neither feasible, nor even desirable. Indeed, each context is marked by its own cultural, economic and social factors, which it would be highly unwise to ignore or reduce. It therefore seems essential to reflect on what would be a respectful approach to these fundamental differences, which would make it possible to reduce the problems of form. We would like to advocate enhanced, flexible international cooperation that respects local specificities, while encouraging and structuring the sharing of expertise. Such an approach, based on a better understanding of historical loops and their implications, could encourage more equitable and effective management of risks, particularly industrial and natural risks. First and foremost, efforts could be made to continue and multiply the creation of forums/conferences ensuring continuity of dialogue spaces between countries, experts and practitioners to establish common or interoperable organizational frameworks and technical solutions. Furthermore, the establishment of international agreements (while preserving their ability to adapt solutions to local realities) would provide the necessary guarantee to meet the specific challenges of different countries, while respecting global objectives. Another action would be to strengthen networks of international experts, with the presence of major global companies. These networks would encourage the sharing of knowledge and the exchange of experience. Lastly, the creation of digital information-sharing platforms would facilitate access to data to keep each other informed about the issues at stake and adjust their strategies. By fostering cooperation based primarily on exchange, these actions would reconcile local needs with global objectives, while reinforcing the effectiveness of international regulatory action in the field of industrial risk.

* 1. Conclusion

In this article, we have attempted to synthesize and organize the factors determining differences in risk regulations between countries facing the same hazards. Factors such as experience with disasters, political priorities at different scales, financial capabilities, access to technology and experts, as well as cultural perceptions of risk or the value of life play a central role in the implementation of risk management regulations. Each country, depending on its history, resources and values, defines its own legislative framework for risk management, reflecting its needs as well as its constraints. This leads to significant disparities in the protection of people, property and the environment, and can impair the ability of coordinated multinational responses to large-scale events. Political, institutional and socio-economic factors (parts 2 and 3) tend to settle over time, gradually shaping cultural and historical frameworks (part 4). In this way, a historical loop emerges immediate responses to crises and political priorities end up becoming the cultural anchors that will in turn influence future choices. Current regulations are therefore both the product of a historical legacy and an adaptation to contemporary needs and challenges. A progressive harmonization of regulations could, in theory, facilitate better international cooperation, reduce inequalities in terms of protection and simplify economic exchanges. However, such harmonization must be approached with caution, to avoid the pitfall of standardization that would negate specific features, economic constraints and cultural sensitivities. Nevertheless, we believe it is both necessary and opportune to pursue efforts in the direction of cooperation and interoperability to meet the challenges of the future.

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