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Corporate environmental infringement, legal regulation, and sustainable development: punitive damages as a perspective

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In order to maximize personal interests, enterprises have a tendency to choose environmental pollution in exchange for corporate profits, resulting in negative externalities; the Civil Code of the People's Republic of China imposes legal regulations on the environmental infringement of enterprises in order to achieve the maximization of the use of the allocation of social resources and promote the sustainable development of society. Subsequent judicial interpretations have set a two-fold cap on the amount of punitive damages. However, in cases of extremely serious environmental damage, the two-fold cap on punitive damages for environmental infringement will create the possibility of insufficient compensation. Based on this, this paper analyzes the legal text of China's punitive damages provisions for environmental infringement and analyzes the interrelationships between enterprises and between enterprises and potential environmental infringement victims in a game analysis. The results of the analysis show that as the amount of punitive damages for environmental infringement increases, the probability of the infringed person filing a lawsuit and that of the enterprise reducing its environmental infringement behavior also increase. In order to promote the cause of China's sustainable development, this paper puts forward relevant suggestions for the improvement of China's environmental legal regulation: first, the upper limit of the amount of punitive damages for environmental infringement should be canceled; second, the amount of reasonable punitive damages should be set on the basis of the damages caused by environmental infringement on human beings and the environment; lastly, in the baseline setting of the amount of punitive damages, additional factors need to be taken into account, and the amount of punitive damages should be set for the enterprises with a high degree of maliciousness. Finally, additional factors need to be considered in setting the benchmark for the amount of punitive damages, which should penalize the enterprises causing environmental infringement with a high degree of malice with heavier penalties and, at the same time, penalize the enterprises with a smaller scale of operation and economic strength with lighter penalties.

KEYWORDS

environmental infringement, punitive damages, legal regulation, sustainable development, legal text analysis, game analysis

1 Introduction

The concept of green sustainable development not only reflects the Chinese people's vision of a beautiful China but also the Chinese government's commitment to preserving the ecological environment instead of prioritizing short-term economic growth. However, in the actual process of production and operation, enterprises often prioritize individual interests over environmental concerns, leading to the exchange of environmental pollution for corporate profits. This behavior contributes to market failure within a free-running market. The negative externalities resulting from environmental infringement by polluting enterprises are one of the causes of market failure. Although each market participant acts as a rational economic agent, the pursuit of higher economic interests by enterprises through environmental infringement creates a conflict with the collective rationality of society, undermining others' rights to a cleaner environment and corresponding economic benefits. Restoring the polluted ecological environment necessitates increased investments from the government in terms of manpower, financial resources, and materials, resulting in escalating social costs. When the social costs far exceed the production costs of the polluting enterprises, inefficient utilization of the scarce social resources occurs. Environmental infringement, categorized as "large-scale infringement," has become increasingly prevalent in China in recent years. Relying solely on the market's inherent dynamics cannot effectively address this wastage of social resources. Therefore, the establishment of relevant laws to regulate the production and operation of enterprises within the market becomes imperative to achieve coordinated economic development and environmental preservation, thereby fostering sustainable development and mutual respect between humans and nature.

Most environmental infringement cases exhibit characteristics such as crossing administrative boundaries and geographic regions, making them highly complex. The establishment of punitive damages is crucial as it involves the deterrence level for the infringer and the extent of compensation for the victims' damages. However, the existing judicial interpretations only set a limit of up to double the amount, which is insufficient in the judicial practice of environmental infringement cases. For example, the first case in China on punitive damages in the field of environmental infringement after the official implementation of the Civil Code was the following: in 2018, a defendant company in Fuliang County, Jiangxi Province, China, experienced a malfunction in its chemical hazardous waste processing equipment during industrial production. This resulted in the inability to treat the generated wastewater, waste materials, and other industrial waste in an environmentally friendly manner. The company entrusted a third party without the necessary permits to dump the waste in the mountains, violating the relevant laws on national environmental protection and hazardous waste discharge. The pollution severely affected water sources and the local residents' access to clean drinking water. The pollutants would also have long-term impacts on the environment and society. To demonstrate the judicial protection of environmental public interests, the court adhered to the principle of comprehensive compensation. It explicitly stated that ecological civilization construction is related to the life, health, and sustainable development of the Chinese nation. Therefore, it is necessary to protect the ecological environment with the strictest rule of law. The court applied the punitive damages clause for environmental pollution and ordered the defendant company to pay three times the amount as punitive damages.

After the verdict, the defendant company realized the damage it had caused to the local ecological environment and the hindrance to normal production and livelihood. They sincerely repented, apologized, complied with the judgment, and fully paid for the ecological environment restoration and punitive damages. However, with the issuance of judicial interpretations, similar cases or those involving more severe environmental infringement would only be liable for compensation within double the amount. This lower–upper limit renders the punitive damages clause of the Civil Code virtually ineffective in deterring polluting enterprises. Therefore, an in-depth exploration is necessary to set reasonable punitive damages and better address environmental infringement by polluting enterprises.

Existing studies have primarily focused on the question of whether punitive damages should be applied in the field of environmental infringement in China. Among them, the majority of scholars are in favor of this approach. Zhou et al. (2018) believed that the application of a punitive damages system in the field of environmental infringement has inherent advantages and is highly feasible for maintaining China's environmental resources. They proposed conducting in-depth explorations and research on the topic and introducing the principle of punitive damages in various types of environmental litigation. Du (2019) stated that environmental pollution encompasses a wide range of fields, and the resulting environmental damage affects unspecified social groups. They argued that relying solely on compensatory damages is insufficient to punish and deter all the perpetrators of environmental pollution. The principle of punitive damages, on the other hand, can achieve deterrence by punishing environmental infringers and deterring potential violators. Peng et al. (2019) argued that the damage caused by environmental pollution is significant, and compensatory damages alone cannot fully compensate for the resulting harm in environmental civil public welfare litigation. They suggested that punitive damages can help address the uncompensated portion of the damage. Gu et al. (2021) argued that punitive damages are a system in the private law system that carries out the functions of public law in terms of punishment and deterrence and that they are a practical necessity for the inadequacy of law enforcement and have institutional legitimacy. Song et al. (2022) believed that the introduction of punitive damages regulation in the field of environmental infringement is a response to the increasingly serious ecological and environmental problems, not only to "fill the loss" as the core of the environmental infringement of the civil remedies system but also for the compensation of the loss of social and public interests to provide institutional innovation. Liu (2023) believed that the codification of China's environmental code has entered the official field of vision and should be problem-oriented; it should seriously sum up the experience of ecological civilization

practice to carry out the design of the environmental code system, which can and should include a punitive compensation system for environmental damage. Kang (2023) argued that under the functionalist perspective, punitive damages for ecological and environmental damages are a product of the fusion of public and private laws, which manifests itself in the form of public law punitive damages and private law activation. Punitive damages activate the public regulatory function of ecological and environmental damage litigation, responding to the problem of insufficient deterrence in environmental governance. However, there are a few scholars who oppose the introduction of punitive damages in the field of environmental torts. For instance, Wang and Gong (2021) argued that when punitive damages are included in public interest litigations, their function deviates from the intended purpose of punishment in private law. Therefore, they argued that it is not appropriate to apply punitive damages to environmental torts within the specific domain constructed by the Civil Code. This approach avoids duplicating punitive damages between private interest torts and public interest torts in the environmental field and maintains the coherence and consistency of the legal system. Cheng (2023) argued that although the punitive damages system can play a deterrent role by replacing or supplementing public law sanctions, it is also prone to lead to duplication of the function of legal liability or the problem of excessive sums and should, therefore, be treated with caution in the application of the punitive damages system in the field of environmental torts. Gao (2023) believed that with the ecological environment damage-related identification standards gradually issued, its technical content is increasingly high, not only detached from the common sense of life but also beyond the general understanding of the enterprise. The perpetrator's actual responsibility to bear the ability to predict has been seriously detached, so it is not appropriate to normalize the field of environmental torts and the application of punitive damages provisions on a large scale. Zhou (2023) asserted that the imposition of punitive damages undermines the traditional civil liability principle of "making the injured party whole." If this divergence is not properly resolved, it will lead to confusion in the environmental civil liability system, resulting in the indiscriminate mixing of various provisions and systems in different types of environmental civil litigations.

Comprehensive studies on the application of punitive damages in the field of environmental infringement in China have primarily focused on the legal implications and the relationship between punitive damages and environmental infringement. However, there is a lack of research from a micro perspective, specifically examining how the amount of punitive damages should be determined and how it applies to enterprises and the infringed parties.

To address this gap, this study aims to analyze the relevant laws and regulations in China and conduct a game analysis to understand the dynamics between enterprises and the potential victims of environmental infringement. By examining the impact of the legal regulations on the behavior of enterprises regarding environmental infringement, the study will provide suggestions for improving the punitive damages system for environmental infringement in China. These suggestions are intended to facilitate sustainable development.

2 Materials and methods

This study aims to examine the need and appropriate level of punitive damages provisions for environmental infringement in China, utilizing legal text analysis and game analysis. The related research process is shown in Figure 1.

2.1 Legal text analysis

Article 1229 of the Civil Code establishes the liability of the infringer for environmental infringement, stating that anyone who causes harm to another person through environmental pollution or ecological destruction shall be held accountable. The application of punitive damages for environmental infringement, as outlined in the Civil Code provisions, is subject to certain conditions. First, the act must constitute a violation of environmental laws; punitive damages cannot be applied if the act does not violate the legal provisions. Second, the perpetrator's subjective mindset in committing the environmental infringement must reach the level of intent, which distinguishes it from the compensatory damages provision in Article 1229 of the Civil Code, where intent is not required. Third, the infringement must result in significant damages, and there must be a causal relationship between the act and the outcome. Finally, only the infringed party has the right to file a lawsuit seeking punitive damages (Li, 2020).

The provisions in the Civil Code reflect the unique characteristics of "illegality," "intent," responsibility, and special subjectivity in the application of punitive damages in environmental torts (Chen, 2020), establishing the guiding principles for punitive damages in environmental tort cases. These provisions build upon the framework of compensatory damages for environmental infringement.

2.2 Game analysis

Game analysis can determine the behavioral decisions of participants in hypothetical scenarios. In the context of punitive damages provisions for environmental infringement, the main stakeholders are enterprises and residents. Enterprises represent potential environmental infringers, while the residents represent potential victims of environmental infringement. This study focuses on two groups: enterprises *versus* enterprises and enterprises *versus* potential victims. By examining the attitudes of both sides toward environmental infringement, a game analysis is conducted.

2.2.1 The game between enterprises without legal regulation

Enterprises engage in a game regarding whether or not to commit environmental infringements. Analyzing this game between enterprises can address the question of the necessity of implementing punitive damages provisions for environmental infringements in the absence of legal regulation.

2.2.1.1 Basic hypothesis

In this scenario, two different enterprises participate in the game. In an undifferentiated market and environment without

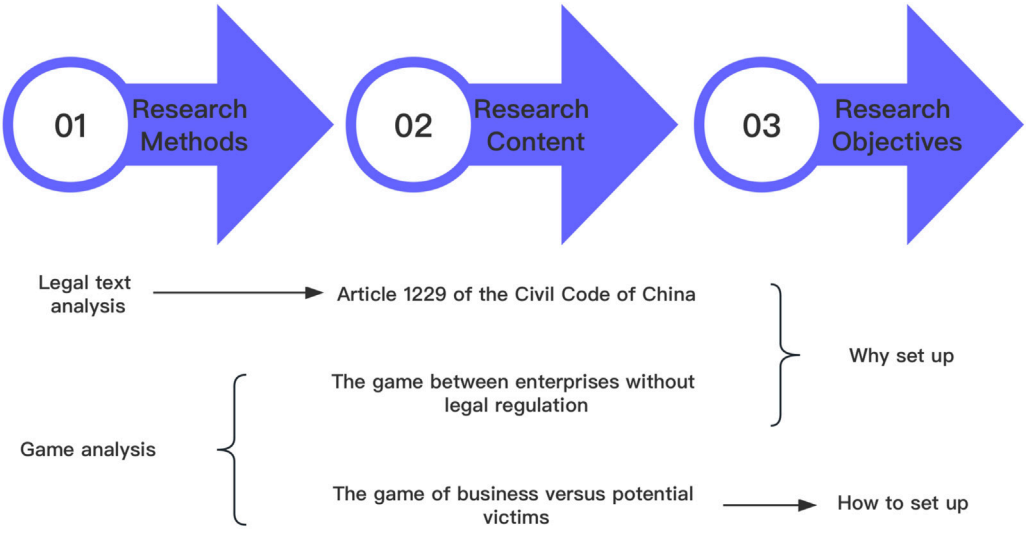

FIGURE 1
Research process.

TABLE 1 Game matrix between enterprises without legal regulation.

		Enterprise B	
		Protect the environment	Pollute the environment
Enterprise A	Protect the environment	(R_A-C, R_B-C)	(R_A-C, R_B)
	Pollute the environment	(R_A, R_B-C)	(R_A, R_B)

legal regulation, enterprises A and B engage in a static game with complete information. During their production and operation processes, they have two strategic choices: "protect the environment" or "pollute the environment." The "protect the environment" strategy incurs environmental protection costs, while the "pollute the environment" strategy incurs no additional costs.

Based on these assumptions, enterprises A and B have four possible combinations of strategy choices, each resulting in different benefits. To facilitate the analysis, this study defines the following parameters:

R_A: initial total revenue of enterprise A;

R_B: initial total revenue of enterprise B;

C_A: increased environmental protection cost for enterprise A's "protect the environment" strategy;

C_B: increased environmental protection cost for enterprise B's "protect the environment" strategy.

All the variables mentioned above are positive.

2.2.1.2 Model building

Based on the given assumptions and parameter settings, we can determine the revenue functions for enterprises A and B under different strategy combinations. This allows us to construct the game model and present the specific game matrix in Table 1.

2.2.1.3 Gaming analysis

In this game model, both enterprises A and B select the "protect the environment" strategy as socially optimal. However, due to the associated costs, the benefits of this strategy are smaller compared to the "pollute the environment" strategy. Consequently, in the absence of any legal regulation, the unique Nash equilibrium of the game matrix is for both enterprises A and B to choose the "pollute the environment" strategy, which is not in line with the concept of sustainable development, thus leading to the "tragedy of the commons" (Zhong, 2023).

In summary, without legal control, enterprises prioritize maximizing their own economic interests during the production process. They tacitly opt to pollute the environment, disregarding the detrimental effects, resulting in market failure. To achieve sustainable development, it is imperative to implement legal regulations on enterprises to mitigate environmental pollution.

2.2.2 The game of business *versus* potential victims

The establishment of punitive damages provisions for environmental infringement creates a game between enterprises and potential victims. Analyzing this game assists in determining the appropriate settings for punitive damages in cases of environmental infringement.

TABLE 2 Game matrix between enterprises and potential victims of environmental violations with legal regulation.

		Potential victims of environmental violations	
		File a lawsuit	Not file a lawsuit
Enterprises	Protect the environment	(R-xc_1,-C_2)	(R-xc_1,0)
	Pollute the environment	(R-Q,Q-C_2)	(R,-Q)

2.2.2.1 Basic hypothesis

In this hypothesis, a game exists between enterprises and potential victims of environmental abuse. The game assumes complete information and involves strategic choices for both parties. Enterprises can choose to "protect the environment" or "pollute the environment," while potential victims can decide to "file a lawsuit" or "not file a lawsuit." Each choice incurs different costs and benefits for the parties involved.

Based on the given assumptions, there are four strategy combinations between enterprises and potential victims, resulting in varying benefits for each side. To facilitate the analysis, this study defines the following parameters:

R: the initial total return of the enterprise;

xc_1: the enterprise's environmental protection cost, where x represents the environmental protection measures and c1 is the unit cost of such measures;

Q: the potential environmental infringement victim's initial revenue after winning the lawsuit, which corresponds to the damages paid by the enterprise losing the case;

C_2: the fixed cost of prosecution for potential environmental infringement victims.

All the variables mentioned above are positive.

2.2.2.2 Model building

Based on the assumptions and parameters mentioned above, we can construct a game model for the enterprise and potential victims of environmental infringement. The game model considers different strategy combinations and their respective benefit functions. Refer to Table 2 for the specific game matrix.

2.2.2.3 Gaming analysis

It is assumed that the probability of aggrieved individuals filing a lawsuit against a polluting enterprise is denoted by P, and the probability of the enterprise implementing environmental pollution due to infringement is denoted by $P(x)$, where x represents the measures taken by the enterprise to protect the environment. The behavioral function $[P(x) = a]$ is defined for the enterprise's implementation of environmental pollution caused by the infringement, and the behavioral function $[P(x) = b]$ is defined for the enterprise's implementation of environmental protection to avoid the infringement.

The expected return from environmental pollution-causing infringement for the enterprise is the following:

$$\boldsymbol{U}(\boldsymbol{a},\boldsymbol{P}) = (\boldsymbol{R}-\boldsymbol{Q})\times\boldsymbol{P}+\boldsymbol{R}\times(\boldsymbol{1}-\boldsymbol{P}) = \boldsymbol{R}-\boldsymbol{P}\times\boldsymbol{Q}. \quad (1)$$

The expected return from environmental protection to avoid infringement for the enterprise is the following:

$$\boldsymbol{U}(\boldsymbol{b},\boldsymbol{P}) = (\boldsymbol{R}-\boldsymbol{xc_1})\times\boldsymbol{P}+(\boldsymbol{R}-\boldsymbol{xc_1})\times(\boldsymbol{1}-\boldsymbol{P}) = \boldsymbol{R}-\boldsymbol{xc_1}. \quad (2)$$

To find the Nash equilibrium solution of this game's payment matrix, $U(a,P) = U(b,P)$ is solved to obtain $P = xc_1/Q$. This solution reveals an inverse proportional relationship between P and Q. When the probability of aggrieved individuals filing a lawsuit against the enterprise is greater than P, the enterprise's best choice is to opt for environmental protection to avoid infringement. Conversely, when the probability of potential aggrieved individuals filing a lawsuit against the enterprise is less than P, the enterprise is more inclined to pollute the environment and cause infringement in pursuit of greater economic interests. The application of punitive damages increases the value of Q as it includes both compensatory damages and punitive damages. This increase in Q leads to a decrease in P, resulting in a higher probability of litigation for the aggrieved individuals. Punitive damages go beyond compensatory damages and provide additional compensation, thereby incentivizing potential aggrieved individuals to file lawsuits against environmental infringement and compelling the enterprise to cease such behavior. However, if the value of Q is small, the corresponding value of P will also decrease. This means that if punitive damages are not applied to environmental infringement or if the amount of punitive damages is set too low, some victims may be deterred from filing lawsuits due to various reasons. This undermines the deterrent effect of punitive damages on the enterprise and hinders their positive incentive function.

3 Discussion

Based on the analysis of the legal texts and game theory, this study further examines the following three key issues related to punitive damages provisions: the necessity of punitive damages, the limitation of punitive damages, and the determination of punitive damage amounts.

3.1 Urgency of punitive damages provisions

In economics, incentives play a crucial role in motivating individuals to respond in certain ways. Rational economic agents in a market carefully weigh the benefits and costs associated with their behaviors and choose the options that offer the highest benefits at the lowest costs. When the incentives change, people adjust their decisions accordingly. The fundamental function of the law is to alter these incentives. Enterprises, driven by the pursuit of economic maximization, naturally seek to maximize their profits. In the absence of relevant regulations, environmental pollution caused by production processes does not generate additional costs for businesses but rather increases their economic gains. Consequently, enterprises often opt to pollute the environment to

TABLE 3 Relevant provisions on punitive damages in China.

Areas covered	Basis for punitive damages amounts	Punitive damages multiplier
Consumer protection	Price of goods or services purchased by the victim or the amount of damage caused	3
	Amount of damage caused by infringing enterprises	≤2
Food safety	Price of goods purchased by the victim	10
	Amount of loss suffered by the victim	3
Trademarks	Losses suffered by the victim or benefits received by the infringing enterprise or the cost of licensing the trademark in question	1–5

boost their earnings as there is no economic incentive to address pollution.

However, when punitive damages are applied to environmental torts, such as those specified in Article 1232 of the Civil Code, the illegal costs for polluting enterprises rise, preventing them from profiting from environmental infringements. Under the influence of punitive damages, enterprises driven by higher economic interests compare the illegal costs associated with polluting the environment with the preventive costs of protecting it. They then choose the lower preventive cost and devise development strategies that prioritize environmental preservation to avoid the potential costs of punitive damages. By doing so, they cease environmental infringements and internalize the negative externalities, ultimately maximizing the overall interests of the community.

3.2 The limitation issue of punitive damages

To achieve sustainable development and effectively manage environmental resources, society must consider the option of implementing punitive damages for intentional environmental destruction. However, determining the optimal approach to maximize social wealth in this context requires careful trade-offs. The effectiveness of punitive damages lies in ensuring that the social benefits of imposing penalties on entities responsible for environmental infringement outweigh the negative impacts and production costs incurred. Thus, it becomes crucial to establish appropriate punitive damages amounts in the environmental domain. The size of the compensation should reflect both the deterrence against offenders and the compensation for the victims' losses. In addition to environmental infringement, China's legal framework provides for punitive damages in various sectors, such as consumer protection, food safety, and trademark infringement (refer to Table 3).

In comparison to the varying upper limits of the punitive damages mentioned above, the punitive damages for environmental infringements are situated at the lowest tier. This falls short and necessitates stricter punitive damages for companies engaged in environmental infringements. The specific reasons for this are as follows:

First, the concept of sustainable development reflects China's commitment to protecting the environment and emphasizes the need for ecological efficiency. It recognizes the importance of balancing economic and social development with the capacity of natural resources and the environment. To achieve sustainable development, it is crucial to strengthen punishments for environmental infringements and promote the development of the eco-economy. The concept of ecological economy aligns perfectly with sustainable development, shifting the focus from maximizing economic benefits to pursuing both ecological and economic benefits. This approach ensures the protection of natural resources, such as the atmosphere, freshwater, oceans, land, and forests, which are essential for the wellbeing of future generations. Therefore, society should not solely prioritize economic wealth but also integrate the concept of green ecology into social development, fostering sustainable and green development. The current social development highlights the conflict between unlimited economic needs and the limited resources of the natural environment. The traditional focus on economic growth alone is insufficient to meet the requirements of environmental protection. It is imperative to transition to a circular economy model to address this challenge. Sustainable development, with its emphasis on harmonious coexistence between humans and nature, holds the key to the fate of humanity. The application of punitive damages in environmental infringement cases is a response to environmental challenges and an embodiment of the civil law's commitment to protecting human dignity and individual freedom in the era of ecological civilization. By implementing stricter punitive damages for environmental infringements, enterprises will be incentivized to eliminate pollution and promote the early transformation of China's economic development. This, in turn, will lead to sustainable development and ensure environmental responsibility for the present and future generations.

Second, Article 1229 of the Civil Code in China addresses the liability for environmental infringement based on the nature of such infringements. It adopts the principle of compensatory damages, whereby the perpetrator of an environmental infringement is required to compensate the victim for all losses caused by the infringement. The compensation is not based on the infringer's own profits but rather on the actual losses suffered by the victim. For example, if the victim incurs losses of 1 million yuan due to environmental infringement, and the infringer makes a profit of 1 million yuan, the infringer must bear the liability for 1 million yuan in damages. This principle ensures that the infringer does not profit from the infringement and that the victim receives comprehensive compensation for their losses. Even when the infringer's profits are lower than the damages suffered by the victim, Article 1229 of the Civil Code maintains a certain level of punitive effect, aligning with the pursuit of justice in legal philosophy (Chen, 2016). However, the reason why the principle

of punitive damages is applied again on the basis of the principle of compensatory damages is because the law is characterized by lagging behind, and only through innovation can the legislation make progress and promote the solution of environmental public interest issues. By its very nature, Article 1232 of the Civil Code is an aggravating circumstance based on compensatory damages for environmental violations. From the expression of the law, Article 1232 of the Civil Code not only protects the private interests of the individual infringer but also serves to protect the public interest of the society. The application of punitive damages so that the infringer is already liable to fill a more unfavorable position, increasing the cost of the infringer's violation of the law, can be more conducive to the maintenance of environmental resources and social public interests. Third, in China, whether it is for consumer rights protection, food safety, or environmental protection, the application of punitive damages serves not only to protect the private interests of individuals but also to safeguard the public interests of the society as a whole. Therefore, the application of punitive damages ultimately aims to protect the public interest. In the case of protection of environmental resources, the emphasis on social public interest is more pronounced, and the depth of involvement is greater, necessitating a more stringent application of punitive damages. In summary, the current cap of two-times the amount for punitive damages in the field of environmental infringement in China is clearly insufficient. A more rigorous approach to addressing environmental infringement is needed.

3.3 Determination of the amount of punitive damages

The application of punitive damages for environmental infringement aims to curb malicious environmental pollution by enterprises during their daily production while also incentivizing them to reduce pollution behaviors that have not yet reached the threshold of legal violation. However, it is important to note that setting higher compensation amounts for punitive damages does not necessarily guarantee better outcomes. Punitive damages for environmental infringement should not be limited by the amount of damages or environmental restoration costs. Excessive costs imposed on polluting enterprises can create excessive pressure and hinder their flexibility in subsequent business activities, ultimately impeding the healthy development of the social economy. Therefore, the setting of punitive damages for environmental infringement should be reasonable and moderate to achieve the social optimum and minimize the social cost of environmental protection.

Based on the above analysis of the game between the producer and the potential victims, it is assumed that the total damage is caused by the polluting company's infringement of the consequences of A, which includes the damage caused by the enterprise's environmental infringement of the consequences of the damage caused by the victims and the consequences of the damage caused by the contaminated environment. At this time, the polluting enterprise's best environmental protection measures should be the cost of prevention, and the polluting enterprises should bear the cost of damages and liability cost minimization, with the following results:

$$\boldsymbol{MIN}\left[\boldsymbol{xc_1} + \boldsymbol{P}(\boldsymbol{x}) \times \boldsymbol{Q}\right]. \tag{3}$$

The social optimal state requires that the polluting enterprise's cost of prevention and environmental pollution caused by the sum of the damages caused by the tort to be minimized, with the following results:

$$\boldsymbol{MIN}\left[\boldsymbol{xc_1} + \boldsymbol{P}(\boldsymbol{x}) \times \boldsymbol{A}\right]. \tag{4}$$

In order to minimize the social cost, the cost of environmental protection measures must let the enterprise's best environmental protection measures to be equivalent to the social optimal state, with the following results:

$$\boldsymbol{MIN}\left[\boldsymbol{xc_1} + \boldsymbol{P}(\boldsymbol{x}) \times \boldsymbol{Q}\right] = \boldsymbol{MIN}\left[\boldsymbol{xc_1} + \boldsymbol{P}(\boldsymbol{x}) \times \boldsymbol{A}\right]. \tag{5}$$

The solution is $Q = A$, which is the total amount of damages borne by the enterprise to be able to fully compensate for all the damage it caused to the people and the environment. As the total amount of environmental infringement damages is Q, including compensatory damages and punitive damages, then the difference between Q and the amount of compensatory damages is the specific amount of punitive damages.

3.4 Additional considerations for punitive damages

Additional factors should be considered when determining the amount of punitive damages for environmental violations. Taking these factors into account can enhance the flexibility of applying punitive damages provisions in environmental infringement cases.

3.4.1 Degree of subjective badness

The selection of punishment should align with the level of severity of the infringement. Therefore, when determining punitive damages for environmental infringement, it is essential to consider the subjective level of severity exhibited by the defendant.

In cases of environmental infringement, the subjective level of severity of the polluting enterprise must reach the intentional level, but there are different degrees of intentionality within this range. When a polluting enterprise intentionally pursues the resulting pollution damage, it demonstrates a direct and malicious intent. On the other hand, if the polluting enterprise is aware of the pollution damage caused but shows indifference by not taking corresponding remedial measures, it falls under the category of indirect and malicious intent. Environmental infringement can also be categorized as either direct infringement, where the actor directly affects the environmental elements, or indirect infringement, where the actor affects the personal and property rights of individuals through the environment, ecology, or other mediums.

Additionally, it should be considered whether the polluting enterprise has previously committed similar environmental infringements and been subjected to punitive damages but continues to repeat such behaviors. This scenario indicates that the polluting enterprise has failed to acknowledge the harm caused by its infringements or persists in repeating the offenses without remorse, implying a higher level of malicious intent.

3.4.2 Business scale and economic strength of the enterprise

When applying punitive damages to a tort, it is important to consider the economic situation of the tortfeasor. In legal economic analysis, the opportunity cost of committing the same act varies for different actors in the society. Therefore, applying a uniform penalty to polluters of different sizes is not reasonable. There is heterogeneity in the extent to which firms of different sizes invest in environmental protection (Fu et al., 2023). Large enterprises, with their stable business environment and strong capital chain, may not be significantly impacted by the payment of punitive damages, resulting in the possibility of recidivism and undermining the intended incentives and deterrent effect of punitive damages. On the other hand, small- and medium-sized enterprises have weaker economic foundations and face market competition pressure. Imposing the same amount of punitive damages on such enterprises may impose a heavy economic burden, making it difficult for them to sustain their operations. Therefore, when applying punitive damages for environmental infringement, the business scale and economic strength of the enterprise should be considered additional factors.

4 Conclusion and recommendation

With the rapid economic development, the occurrence of environmental pollution by enterprises is increasing. From a legal and economic perspective, environmental resources are scarce, and when enterprises engage in environmental infringement, they externalize negative impacts that undermine the benefits of a clean environment for others, thereby hindering sustainable economic and social development. To promote the harmonization of economic development and environmental protection and achieve sustainable development, Article 1232 of China's Civil Code introduces the principle of punitive damages for environmental infringement. This provision establishes punitive damages for environmental torts based on objective illegality, subjective intentionality, serious consequences, and eligible subjects. The application of punitive damages can raise the production costs for polluting enterprises, incentivizing them to eliminate infringement and gradually realize the sustainable development of society and the economy. Therefore, it is necessary to apply punitive damages provisions to enterprises engaged in environmental infringement.

At the same time, the amount of punitive damages for polluting enterprises should be set at an appropriate level. If the amount is too low, a penalty cannot effectively deter polluting enterprises. On the other hand, excessively high penalties are not conducive to the transition of enterprises toward green production. Only by reasonably determining the amount of damages for environmental infringement can we establish a solid institutional foundation for achieving sustainable development in society and the economy. Based on this, this study puts forward the following suggestions for the improvement of China's environmental infringement punitive damages provisions:

First, China's legislature should eliminate the cap on punitive damages for environmental infringement. The analysis of the relationship between enterprises and potential victims of environmental infringement reveals that the likelihood of victims filing lawsuits decreases as the amount of damages borne by polluting enterprises increases. In cases of severe environmental damage, a legal provision capping the compensation amount may render it insufficient to penalize polluting enterprises. Consequently, aggrieved individuals, considering cost and benefit factors, may be discouraged from filing environmental infringement lawsuits, while enterprises, due to inadequate deterrent effects of punitive damages, may continue engaging in environmental pollution without providing compensation. Thus, removing the cap on punitive damages is necessary to address the issue of insufficient punishment resulting from the cap's existence.

Second, the application of punitive damages for environmental infringement should consider the overall damage caused to humans and the environment as a result of the infringement based on the total compensation amount for environmental infringement. After excluding the compensation amount for the victims, the remaining amount should be designated as the final punitive damages. This approach sets the compensation amount based on the actual consequences of the damage, ensuring objectivity and avoiding excessive or insufficient punishment. Moreover, it facilitates minimizing social costs associated with environmental protection.

Third, when applying punitive damages for environmental infringement, judges should consider additional factors such as the degree of subjective malice exhibited by the enterprise and the scale of its operations. Environmental infringement cases involving direct intentional actions and repeated offenses should receive harsher punishments, thereby expanding the range of punitive damages. Conversely, for enterprises facing pressures to transition to green practices and smaller-scale operations with limited economic strength, a reduction in punishment can be considered. This discretionary reduction in the compensation amount can be implemented alongside the establishment of punitive damages. Overall, this approach enhances the flexibility of applying punitive damages provisions to environmental infringement cases, allowing for better adaptation to different circumstances.

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