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Environmental Protection for Developing Countries: The Polluter-Does-Not-Pay Principle

Abstract

The polluter-pays principle stipulates that the person who damages the environment must bear the cost of such damage. A number of developing countries have recently extended this principle creating an obligation on the state to compensate the victims of environmental harm. This variation of the polluter-pays principle is aimed at ensuring victims' compensation when polluters cannot be identified or are insolvent. These regimes hold state and local governments primarily or jointly-and-severally liable for environmental damage and allow the government to act in subrogation against the polluters. In this paper we study the effect of this form of governmental liability which we describe as the polluter-does-not-pay regime on the polluters' incentives and on aggregate levels of environmental harm. We develop an economic model to study the polluter-does-not-pay principle, identifying the conditions under which this regime may be a more effective instrument for environmental protection. We conclude suggesting that this regime may be desirable in environments characterized by widespread poverty, high interest rates, judicial delays and uncertainty in adjudication.

JEL Codes: K13, K32, Q56
Keywords: environmental protection, polluter-pays principle, state liability

1. Introduction

The polluter-pays principle is an international guideline for environmental policy stipulating that the person or firm who damages the environment must bear the cost of such damage. Since an environmental harm is often an externality, liability induces the responsible party to internalize the full social cost of his activity, thereby bringing the environmental harm down to the optimal level. In this paper, we shall consider a recent trend observed in developing countries such as India, Ecuador, Chile, Costa Rica, Kenya, … which have adopted or considered through judicial, legislative and constitutional reforms a variation of the polluter-pays principle, focused on mitigation of the harm through governmental liability. These new regimes have been advocated to ensure victims' compensation when polluters cannot be identified or are insolvent.

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Subverting the original rationale of the polluter-pays principle, these regimes suggest that the primary aim is to provide prompt compensation to the victims of environmental harm, and only secondarily to impose liability on the responsible parties. In this context, in the last few decades several legal systems have recognized a primary obligation on local and central governments to provide prompt relief and compensation to victims of environmental harm. This is a distinct shift from the regime of the polluter-pays regime, a shift that we shall refer to as the *polluter-does-not-pay* regime.

This paper is structured as follows. In Section 2 we provide a brief history of the polluter-pays principle and of its recent demise in the practice of developing countries, with special reference to the case of India. In Section 3 we develop a model to consider the incentive system created by a polluter-does-not-pay regime on prospective injurers and to evaluate the effects of this regime on the aggregate levels of environmental harm. In Section 4, we examine the comparative advantage and the welfare properties of the polluter-does-not-pay regime as an instrument of environmental control in developing countries. We consider the welfare properties of the polluter-does-not-pay regime, comparing its effects to those that would be induced by a benevolent, welfare-maximizing government. Section 5 concludes with some policy considerations.

2. The Polluter-Does-Not-Pay Principle

In Section 2.1 below, we provide a brief history of the polluter-pays principle, and in Section 2.2 we shall address the demise of this principle in the practice of developing countries, with special reference to the case of India.

2.1 The Rise and Fall of the Polluter-Pays Principle

The adoption of the polluter-pays principle had long been recommended by academics, and was the basis of formal recommendations of the Organization for Economic Cooperation and Development (OECD) since the early 1970s.[1] The

[1] The Organization for Economic Cooperation and Development (OECD) expresses the economic function of the polluter-pays principle as forcing "prices of goods (depending on the quality and/or

extensive work of the OECD over the subsequent two decades was responsible for metamorphosing this economic principle into an established legal principle.[2] The polluter-pays principle was formally adopted by the Europe Union in the Single European Act of 1987.[3] The polluter-pays principle originally applied only to those actually "polluting" the environment with emissions etc, in the strict sense of the word. The principle was subsequently extended to apply to any activity which contributes to deterioration of the environment.[4]

The implementation of the polluter-pays principle by sovereign states has enjoyed different incarnations in national legal systems overtime.[5] In some situations, the polluter-pays principle is implemented by state governments through direct regulation creating economic incentives, leading the polluter to bear the cost of the environmental harm caused by its activity. Typically this is done through regulation imposing direct environmental liability on the polluting agents. In the context of environmental liability, in the last few decades, international and national environmental liability laws are invariably based on strict liability.[6] The proponents of the strict liability rule also focus on "cost internalization," which requires that the social cost of an activity is charged to the polluter. This is consistent with the economic rationale of the polluter-pays principle, which mandates the cost-

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quantity of environmental resources) to reflect, more closely, their relative scarcity and that economic agents concerned react accordingly". OECD: *On guiding principles concerning international economic aspects of environmental policies*, C (72) 128, 1972, Paris, France. Also see, OECD: *The polluter-pays principle. Note on the implementation of polluter-pays principle*, 1974, Paris, France.

[2] OECD: *The Polluter-pays principle: OECD Analyses and Recommendations*, Doc. OCDE/GD(92)81, 1992, Paris, France, at 9.

[3] Single European Act, 17 Feb. 1986, 1987 OJ (L 169) 1.

[4] On some occasions, this is referred to as the "extended polluter-pays principle."

[5] Førsund R. Finn., "The Polluter-pays principle and Transitional Period Measures in a Dynamic Setting"; *The Swedish Journal of Economics*, Vol. 77, No. 1, Public Finance: Allocation and Distribution, (March 1975), pp. 56-68.

[6] Commission of the European Communities. Communication from the Commission to the Council and Parliament: Green Paper on Remedying Environmental Damage, COM(93)47 final. Brussels, 14 May 1993. Although negligence is the dominant rule in tortuous liability as opposed to strict liability (which is reserved usually for cases involving hazardous activity), the form of liability typically seen in environmental pollution and degradation is strict liability, or no fault liability, rather than negligence. There may be other charges faced according to the civil and criminal laws of the particular jurisdiction, but strict environmental liability remains the dominant rule.

internalization principle.[7] The economic rationale for this is that strict liability is a preferable rule in situations of unilateral care and where only the injurer can take effective precautions to prevent the harm. Further, while both strict liability and negligence rules induce the injurer to take the optimal amount of care, the advantage of strict liability in environmental cases is that only the harm must be observable. The level of care is irrelevant and therefore need not be established in a court of law, thereby reducing evidentiary requirements. The other reason for the increasing use of strict liability in environment protection, especially in an age where all governments are trying to curb industrial pollution, is that in a market setting, negligence may prove inefficient compared to strict liability, inasmuch as it does not create adequate incentives to reduce activity levels and to invest in research and development of new cleaner technologies. Furthermore, residual damages caused by partially controlled polluting activities would not be reflected in the price of commodities, resulting in resource misallocation.[8] Under the negligence rule, in those industries there could therefore be excessive entry of firms, with a resulting increase of the probability of pollution and/or environmental damage.[9]

In cases of environmental pollution and degradation in developing countries, a different variation of the polluter-pays principle, focused primarily on the need to provide immediate compensation to victims of environmental harm, has emerged.[10] This variant of the polluter-pays principle generally sees a primary role on local and

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[7] Bergkamp Lucas, "Liability and Environment Private and Public Law Aspects of Civil liability for Environmental Harm in an International Context", Draft 10, April 2001, downloaded from

http://papers.ssrn.com/paper.taf?abstract_id=266365 on July 5 2008.

[8] Krier James E. and Stewart Richard B., "Environmental Law and Policy: Readings, Materials and Notes", 1978, 2d ed., Indianapolis, USA.

[9] Polinsky A.Mitchell, "Strict Liability vs. Negligence in a Market Setting", *Journal of American Economic Association*, May 1980 on page 363. On the other hand, under a strict liability regime, there would be an excessive entry of victims. Since most countries have their goal as reducing and penalizing pollution (as opposed to an optimal number of victims and lawsuits), strict liability is regarded as a more desirable implementation of the polluter-pays principle.

[10] Pigouvian taxation instruments, involving a direct tax on every unit of pollution or on every unit produced by the polluting activity, have also been considered as alternative implementations of the polluter-pays principle. A third way in which the polluter-pays principle has been interpreted and implemented by national governments is through the adoption of market based instruments, such as pollution permits and bubble-type pollution allowances. In yet other situations, the polluter-pays principle is interpreted broadly and is implemented through command-and-control measures wherein the government may specifically prohibit certain environmentally dangerous activities or disallow certain products, methods, or scientific techniques.

central governments to provide compensation to victims of environmental harm virtually subvert the logic of the principle, suggesting that the primary purpose of the principle is to provide prompt compensation to the victims of environmental harm, and only secondarily allows governments to act in subrogation to recover damage payments from the responsible parties. This quite drastic shift away from the strict liability regime of the polluter-pays principle is best illustrated by the recent developments in environmental protection in India, which we refer to as the polluter-does-not-pay principle. [11]

2.1 Governmental Liability for Environmental Harm: The Case of India

Non-governmental organizations, Indian courts and policymakers have been looking for solutions to India's environmental problems.[12] One such measure was the application of the polluter-pays principle in Indian environmental law and the many creative interpretations of the principle adopted by the Indian judiciary. India recently adopted a system of direct governmental liability requiring the state to pay damages to the victim of environmental harm and allowing the government only to recover its disbursements from the polluter at a later time through an action for subrogation. In the following, we shall refer to this regime as the polluter-does-not-pay principle.

The touchstone for Indian environmental legislation was the Stockholm Declaration in 1972. India agreed with 113 other nations on principles and an action plan to protect the environment and came under an obligation to implement these domestically. In the fulfillment of the obligations arising from the Stockholm Declaration, India has witnessed a proliferation of environmental laws and regulations. In keeping with international standards, the Indian government enacted legislation for environmental protection, water pollution, air pollution and wildlife conservation. Most notably, the implementation of the Stockholm Declaration led to

[11] Further analysis of the various legislation and environmental cases can be found in Jaswal Paramjit S, "Environment Law", 2008 Edition, Allahbad Law Agency, Faridabad India, which has provided a comprehensive source of information for this section.

[12] The World Bank has predicted that India's water, air, soil and forest resources will be under more human pressure than those of any other country by the year 2020.

the amendment of the Indian Constitution, which incorporated Articles 48A[13] and Article 51A (g).[14] On the basis of these constitutional provisions, the Indian Parliament enacted the Water Act, 1974, Air Act, 1981, and the Environmental Protection Act, 1986.[15] The Water Act, 1974 was the first of several pieces of legislation passed in India following the Stockholm Declaration. This was the first environment-related legislation passed in India, with the objective of ensuring that domestic and industrial pollutants not be discharged into rivers and lakes without adequate treatment. The government set up Pollution Control Boards and standards for factories discharging pollutants into bodies of water under this legislation. The most important feature of the Act was that it permitted the relevant authority to order the closure of non compliant industries. The Air Act, 1981 was also drafted on very similar grounds to prevent and control air pollution. The Environmental Protection Act, 1986 gave the government extensive power to monitor and regulate industries. The Act empowered the Indian government to make rules and regulations, formulate standards, prescribe procedures for managing hazardous substances, regulate industries and establish safeguards for preventing accidents.[16] It also empowered the government to set up parallel regulatory agencies for roles such as to protect specific parts of the environment and also to delegate its powers to such an agency. The legislation and its Rules clearly incorporated the polluter-pays principle and imposed civil liability for non-compliance. The Act also provided for criminal punishment for non-compliance with environmental standards.[17] The Control and Regulation of Hazardous and Solid Wastes under Environment Protection Act, 1986 specifically empowered the government to protect the environment from hazardous substances. The Act and its Rules incorporated the polluter-pays principle and no-fault liability for accidents involving hazardous substances. It specifically provided for the liability

[13] Article 48A is a Directive Principle guiding the state for the "protection and improvement of environment and safeguarding of forests and wild life.

[14] Article 51A(g) is a Fundamental Duty for the citizens of India India to "protect and improve the natural environment.

[15] Kumari Areti Krishna, "Evolution of Environmental Legislation in India", January 2007, downloaded from SSRN at http://ssrn.com/abstract=956228 on July 30 2008.

[16] Section 3, Environment Protection Act, 1986.

[17] Section 15, Environment Protection Act, 1986.

of the occupier, transporter and operator of a facility handling hazardous waste and enforced the polluter-pays principle.[18]

The Public Insurance Liability Act was perhaps conclusive evidence for the polluter-pays principle being applied in Indian environment law. This was the first time the government acknowledged absolute liability for accidents due to hazardous substances. The Act specified how much compensation was to be paid for every degree of injury or death of civilians and/or workmen.[19] The Act mandated owners of facilities employing hazardous substances to take out insurance policies for accidents. The Central government also created an Environment Relief Fund under which owners could make payments equal to their insurance policy and use the fund to pay compensation in case of accidents.

In conjunction with these regulations, specialized authorities have been set up with the grant of wide powers including closure of industries and the power to give any directions to protect the environment.[20] Yet these authorities suffer from administrative failures similar to those plaguing the rest of the Indian bureaucracy and executive. Cities and rivers in India, in particular, underwent unprecedented degradation. With rising environmental degradation, the increasingly activist Indian judiciary began to take greater note of these standards and tightened the enforcement of these laws. In order to shake up this situation, the Indian judiciary reinterpreted the polluter-pays principle, creating an obligation of state governments to provide compensation to the victims of environmental harm, when not successfully prevented by the proactive precautionary measures of the specialized authorities.

The Indian judiciary took special interest in this matter on counts of social justice as thousands of poor Indians were drinking contaminated water or dying of respiratory diseases. Most of the victims of such environmental degradation had no possible means of individually suing the polluters. Although Indian law recognizes a class suit or a representative suit, wherein one or more members of a class having the

[18] Rule 16, The Hazardous Wastes Management and Handling Rules, 1989.

[19] Section 3 read with the Schedule of the Public Liability Insurance Act, 1991.

[20] The Central Pollution Control Board (CPCB) and State Pollution Control Boards (SPCBs) were initially set up under the provisions of the Water Act, 1974, and now also carry out the functions under the Air Act, 1981. The CPCB and the SPCBs also perform all additional functions under this the Environmental Protection Act and are the prime environmental authorities in India. They are supported by the relevant authorities for the supervision of coastal zone regulations; the National Coastal Zone Management Authority and State Coastal Zone Management Authorities.

same interest, may sue or defend on behalf of themselves and all the other members of the class,[21] these actions were used in very few cases and with little success and were not regarded as a viable solution to the problem at hand. The Supreme Court opened an effective venue for such environmental cases by allowing them to be filed as writ petitions ever since it recognized the right to a clean environment as part of the Fundamental Right to Life under Article 21.[22] If the complaint is of a legal wrong, then the High Court of the state can be approached under Article 226 of the Constitution. The right to approach the High Court or the Supreme Court, if any of a person's "fundamental rights" are violated, is included in the fundamental rights chapter of the Constitution under Article 32.[23]

The Supreme Court has used this jurisdiction as enforcer of fundamental rights along with its plenary powers to intervene in cases which, in its opinion, qualify as public interest litigation,[24] relaxing the rules of procedure for filing a petition.[25] The violation of fundamental constitutional rights was recognized in *MC. Mehta v. Union of India,* [26] and followed in a consistent sequence of decisions concerning environmental harm. In all such cases, the Supreme Court held that environmental pollution and industrial hazards were not only potential civil torts, but also violations

[21] Order 1 Rule 8 of the Civil Procedure Code of 1908

[22] Article 21 states 'No person shall be deprived of his life or personal liberty except according to procedure established by law'. The narrow interpretation of this right was that that the state had to demonstrate only that the interference with the individual accorded with the procedure laid down by properly enacted law. However the Supreme Court intended to give substance to this fundamental right as opposed to interpreting it in a narrow procedural manner. Therefore the right to life now extends to many other rights such as; right to livelihood, rights of slum dwellers and hawkers, right to medical care, right to shelter, right to education, right to food, right to privacy, right to a clean environment, and other socioeconomic rights.

[23] Jain MP, "Indian Constitutional Law" 2005 Edition, Wadhwa & Company Nagpur, New Delhi India.

[24] Craig PP and Deshpande SL, "Rights, Autonomy and Process: Public Interest Litigation in India" *Oxford Journal of Legal Studies*, Vol. 9, No. 3, Autumn, 1989, pages 356-373, downloaded from Jstor at http://www.jstor.org/stable/764422 on July 29 2008.

[25] For the above purpose, the Supreme Court diluted the *locus standi* requirements for petitioning the Courts which meant that the victim was no longer required to petition himself, but any public-spirited person to approach the court on behalf of disadvantaged classes or a member of a disadvantaged class (who was unable to approach the court himself by reason of his disadvantage). *SP Gupta* v *Union of India* 1981 Supp SCC 87. The court also streamlined filing formalities, creating a new 'epistolary jurisdiction' in which the court recognized even a letter or post-card sent to it containing a complaint, as constituting a public interest litigation petition.

[26] MC Mehta v Union of India AIR 1987 SC 1086; where the Court laid down the rule of Strict Liability for using substances in a matter where Oleum Gas leaked in a residential area from a chemical factory.

of fundamental rights, redressable directly by the Supreme Court through a public interest petition under Article 32. Since 1987, the Supreme Court has assumed jurisdiction in various environmental cases using the writ of mandamus and intervened in matters such as pollution from tanneries,[27] pollution caused by chemical industries in Delhi,[28] Taj Mahal Pollution case,[29] Ganga River water pollution case,[30] Yamuna River water pollution case,[31] Gomti River water pollution case,[32] pollution due to H Acid case,[33] ban on import of toxic waste case,[34] noise pollution by fire cracker case,[35] mercury pollution in Singrauli case,[36] pollution by chemical industries in Gajraula area case,[37] diesel generator sets case,[38] of regulation of traffic in Delhi,[39] modernization of slaughter houses in Delhi matter,[40] regulation of garbage disposal in Delhi matter,[41] pollution control and check of vehicles matter,[42] and a host of other issues concerning the environment.

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[27] *Vellore Citizens Welfare Forum* v. *Union of India* (1996) 5 SCC 647

[28] *M.C.Mehta* v. *UOI & Others* Writ Petition(Civil)No.4677 of 1985

[29] *M.C.Mehta* v. *UOI & Others* Writ Petition (Civil) No.13381 of 1984

[30] *M.C.Mehta* v. *UOI & Others* Writ Petition (Civil) No. 3727/1985

[31] *AQFM Yamuna* v *Central Pollution Control Board* (2000) 9 SCC 499

[32] *Vineet Kumar Mathur* v. *UOI & Others* (1996) 7 SCC 714

[33] *Indian Council for Enviro-Legal Action* v *Union of India* AIR 1996 SC 1446

[34] *Research Foundation for Science Technology National Resource Policy v. Union of India and anr. (1999) 1 SCC 223*

[35] In Re Noise Pollution - (2005) 5 SCC 733

[36] *M.C.Mehta* v. *UOI & Others* I.A. No. 343/2000 in Writ Petition (Civil) No. 3727/1985

[37] *Imtiaz Ahmad* v. *UOI & Ors.* Writ Petition (Civil) No.418/1998

[38] *The United Communist Party of India* v. *The Union of India & Ors*. CWP No.1640/2001

[39] *Hemraj & Ors*. v. *Commissioner of Police & Ors* CWP No.3419/1999 in the High Court of Delhi

[40] *Buffalo Traders Welfare Association* v *Union of India & Ors*. (2004) 11 SCC 333

[41] *B.L. Wadhera* v *Union of India and Ors*. (1996) 2 SCC 594

[42] *Acti-Recti & others* Vs *UOI & Others* C.W.P. No.3105/1999

2.2 The Rise of the Polluter-Does-Not-Pay Principle

Since fundamental rights are enforceable only against the State, the petitions for environmental liability are filed directly against the federal or state government.[43] Since most of the polluting industries are private enterprises, no writ petition could lie against them.[44] In many such cases, the agency which is responsible for pollution pays for the pollution and the actual polluter does not face an action for subrogation. For example, for the restoration of Yamuna River an action plan with an allotment of almost Rs. 25 billion has been set aside by the government.[45] There are many similar cases involving other rivers in India including the Ganga[46] and Gomti[47], where the Supreme Court has issued orders to the relevant municipal authority to constitute mechanisms to clean the river and compensate victims of pollution.

Even when an action if successfully brought against the polluting firm, the government remains liable to pay for residual shortfalls. In the Bhopal Gas Tragedy,[48] after five years of litigation, an out of court settlement was reached between the polluting company, Union Carbide, and the Government of India. The Supreme Court held that if the settlement fund that was negotiated was exhausted, the Government of India should make good the deficiency for all the claims past, present and future arising from the gas leak.[49]

As a result of these developments, the involvement of state authorities has now changed to a much larger role. The state is now involved in all environmental matters, from creating the appropriate authority to cleaning the environment pollution, to

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[43] Under the Indian Constitution, a writ petition can only be filed for infringement of fundamental rights under Article 32 and such Fundamental Rights are enforceable only against the "State". Under Article 12 of the Indian Constitution as "the State" is defined as to include the Governmental and Parliament of India and the Government and the Legislature of each of the States and all local or other authorities within the territory of India or under the control of the Government of India.

[44] For instance, in the case of Bichchri village, the pollution was caused by private industries. However, the public interest litigation was not filed against these units but against the Union of India, the State Government of Rajasthan and the State Pollution Control Board of Rajasthan, since pollution violated the right to life of citizens under Article 21.

[45] *AQFM Yamuna* v *Central Pollution Control Board* (2000) 9 SCC 499

[46] *MC Mehta* v *Union of India* (1987) 4 SCC 463

[47] *Vineet Kumar Mathur* v. *UOI & Others* (1996) 7 SCC 714

[48] Bhopal Gas Leak Disaster (Processing of Claims) Act, 1985

[49] *Union Carbide Corporation* v *Union of India* AIR 1990 SC 273

actually stepping in for the polluter and paying the damages. This model of governmental liability for environmental harm (the polluter-does-not-pay regime) has been lauded by many as the savior of India's ecology. In Section 3, we will analyze the incentive system created by this regime of governmental liability on prospective injurers and on the aggregate level of environmental harm.

3. A Model

In this section, we present a formal model to compare the incentive and welfare effects of environmental liability considered above. As discussed in Section 2, in a polluter-does-not-pay regime, all cases of environmental tort and environmental accidents can be either filed through public interest litigation directly against state and local government or brought against these governmental bodies through joint-and-several liability actions in torts.[50] In either cases, the amount that is determined as damages will be paid by the state to the victims. The state has an opportunity to act in subrogation against the actual polluters to recover the damages paid to the victims and the cost of environmental restoration.

In these regimes of governmental liability, the primary liability for the environmental damage caused by private firms and individuals falls on the state and local governments. When exercised by the government, the right of subrogation transfers the loss to the responsible party only when such party is solvent, but leaves the loss on the government in case of insolvency. Further, even though the primary liability of the state is immediate and unconditional, the government can recover its financial exposure against the responsible parties with some delay and uncertainty.

We build a simple model to describe the effects of polluter-pays and the polluter-does-not-pay regimes, identifying the conditions under which one or the other are more effective instruments of environmental protection.[51] Under the polluter-does-not-pay regime we characterize the monitoring decision of a government, who faces primary liability for the environmental damage caused by a private individual or firm

[50] In the case of environmental protection in India, this involves filing a writ petition under Article 32 of the Indian Constitution against the state and the polluters.

[51] For a recent analysis of the tradeoff between direct and indirect incentives in the context of state liability, see Dari-Mattiacci, Garoupa and Gomez (2008).

(polluter), who is potentially judgment-proof. We assume that parties (government and polluters) are risk neutral, rational and utility maximizing.

An agent (the prospective polluter) carries out an activity, with a value equal to $V(z)$, where z denotes the activity level. We assume that the value of the activity increases with the activity level in the relevant range, $V_z > 0$, at a decreasing rate, $V_{zz} < 0$. The activity may cause environmental harm. The agent can invest in care to reduce the probability of such environmental harm. Denote with x the agent's level of care per unit of activity z, where $x \in [0, \infty)$. With a level of care x, environmental damage occurs with probability $p(x)$, where $p(x) \in (0,1)$. We assume unilateral care, such that the probability of the environmental damage can only be effectively controlled by the polluter's level of care. The government can affect the polluter's level of care through monitoring but cannot directly reduce the environmental risk by taking precautions on its own.[52] Likewise, the victims bear the harm without being able to reduce the probability of its occurrence with their own precautions. We assume that the agent's care decreases the probability of an environmental damage, $p_x < 0$, at a decreasing rate, $p_{xx} > 0$. When environmental damage occurs, an (exogenous) loss denoted by L[53] is created, where $L > 0$. In the simple economy considered here, there are two types of agent (potential polluters), $i = R, P$. Rich agents, R, are present in number equal to N_R and are characterized by the fact that they have a level of wealth sufficient to compensate for the environmental harm L caused by their activity. Poor agents, P, are present in number equal to N_P, and they have a lower level of wealth, denoted by a, where $a < L$.[54] We shall refer to n as the proportion of poor over rich agents in the population, i.e. $\frac{N_P}{N_R}$.

[52] Relaxing the assumption that the government can only affect the likelihood of environmental damage through monitoring would require a slightly more complex analysis but would not alter the main results of our analysis.

[53] Although polluters can in fact frequently reduce both the magnitude and the probability of the environmental damage that they produce, as it is standard in the literature, we are assuming that the polluter can only affect the probability of the harm, but not its magnitude. This assumption simplifies the model without loss of generality. As shown by Dari Mattiacci and De Geest (2005), the impact of insolvency on the incentives to take precaution is not qualitatively changed when the magnitude of the harm is endogenous.

[54] In the case $a \geq L$ the agent is not judgment-proof and, according to the conventional literature vicarious liability is not a necessary device to induce optimal precaution: direct personal liability would provide the agent with perfect incentives. In the current context, in addition to agents' limited wealth, a second reason that could dilute incentives to enhance precaution is the difficulty in indentifying the responsible party among the many possible agents that could have contributed to the environmental

3.1 The Polluter-Pays Principle: The Limits of Direct Liability

In this section, we will briefly restate the conventional results in the literature concerning the effects of the polluter-pays regime on the level of care, for the two categories of agents considered above.

Proposition 1: *In a polluter-pays regime the privately optimal level of care chosen by type P agents is lower than the level of care chosen by type R agents:* $x_P^* < x_R^*$

This result should not be surprising. The limited wealth of type-P agents reduces their expected liability, hence diminishing the (private) marginal benefit of care. Type-P agents will therefore have a lower incentive to invest in care, x_P[55].

Under this liability regime, the privately optimal levels of care for the two types of agent, x_P^* and x_R^*, are chosen to maximize their respective objective function, represented by the value of their activity at the net of expected liability and precaution costs.

The objective function for a representative type-R agent with wealth $a \geq L$ is:

$$max_{\{z_R, x_R\}} V(z_R) - z_R p(x_R) L - z_R x_R \qquad (1)$$

The objective function for a representative type-P agent with wealth $a < L$ is:

$$max_{\{z_P, x_P\}} V(z_P) - z_P p(x_P) a - z_P x_P \qquad (2)$$

As Expression (1) is convex,[56] from the first-order condition of type-R agents, we have:

$$-p_x(x_R^*)L = 1 \qquad (3)$$

Similarly, as Expression (2) is convex,[57] from the first-order condition of type-P agents, we have:

$$-p_x(x_P^*)a = 1 \qquad (4)$$

where the left-hand-side of (3) and (4) represent the marginal benefit of care (in terms of reduced probability of an accident loss) and where the right-hand-side represents

harm. When problems of this sort arise, a could be interpreted as the fraction of the harm that the agent expects the bear, given the probability lower than one of not being identified or sued.

[55] See Shavell (1986) and Dari Mattiacci and De Geest (2005).

[56] First-order condition: $1 + p_x(x_R)L = 0$. Second order condition: $p_{xx}L > 0$.

[57] First-order condition: $1 + p_x(x_P)a = 0$. Second order condition: $p_{xx}a > 0$.

the marginal cost of care, for the two categories of agents. It should be noted that $p_x(x_P)$ in Equation (4) is clearly less than $p_x(x_R)$ in Equation (3). As $p_{xx} > 0$, it follows that $x_P^* < x_R^*$: in a polluter-pays regime of strict personal liability, type-P agents undertake a privately optimal level of care that is lower than the privately optimal level of care for type-R agents.

Proposition 2: *In a polluter-pays regime, the (privately) optimal activity level for type-P agents is higher than the activity level for type-R agents:* $z_P^* > z_R^*$

The impact of limited liability on the agent's activity level can be derived in a similar way. From the first-order condition of a representative type-R agent with wealth $a \geq L$, we have:

$$V_z(z_R^*) = p(x_R^*)L + x_R^* \qquad (5)$$

In analogous way, from the first-order condition of a representative type-P agent with wealth $a < L$, we have:

$$V_z(z_P^*) = p(x_P^*)a + x_P^* \qquad (6)$$

From inspection of (5) and (6), we observe two countervailing effects. The higher level of care chosen by type-R agents (as shown in Proposition 1) brings the per-unit cost of their activity above that of type-P agents. This induces type-R agents to undertake a lower level of activity than their type-P counterparts. On the contrary, the higher level of care undertaken by type-R agents renders their activity less dangerous, reducing the expected cost of liability per-unit of activity. This may induce a higher level of activity. Similarly to Shavell (1987), from inspection of z'_i[58] we can see that the former effect dominates over the latter.[59] At optimal care level and for equal values of their activities, type-R agents will therefore find optimal to reduce their activity levels below that of type-P agents. In analytical terms, since $V_{ZZ} < 0$ $V_z(z_R^*) > V_z(z_P^*)$ implies that $z_P^* > z_R^*$. In the following analysis of activity levels we

[58] Writing $z_i = z_i(x_i), i = R, P$, we differentiate (5) for a type-R to obtain $z'_R = \frac{p_x(x_R)L+1}{V_{zz}}$. At x_P^* $z'_R(x_P^*) > 0$. Similarly for a type-P agent and and obtain $z'_P = \frac{p_x(x_P)a+1}{V_{zz}}$. and $z'_P(x_R^*) < 0$.

[59] Type-P agents could otherwise improve their payoff mimicking type-R agents' level of care hereby reducing their expected liability.

will similarly assume away these second order effects to allow for a definite sign of the comparative statics effects.

3.2 The Polluter-Does-Not-Pay Principle: Ex-ante And Ex-post Instruments

We can now study the incentives created by the application of the polluter-does-not-pay regime on the two types of agents considered above. This will later allow us to compare the aggregate level of environmental harm under our two liability regimes.

In a polluter-does-not-pay regime, the government is directly liable towards the victims of environmental harm for the losses caused by the agents' economic activities. The government has two instruments for minimizing its exposure to environmental liability. First, the government can act ex ante by monitoring the agents during their economic activity. Monitoring is imperfect and can only affects the level of care undertaken by the agents, hence reducing without eliminating the probability of environmental harm. Second, the government can act ex post in subrogation to recover from the responsible agents all or part of the payment made by government to the victims of environmental harm. Subrogation transfers some of the liability incentives on the agents. The government can adopt different combinations of ex ante and ex post instruments for each category of agents to minimize its overall financial exposure.

When investing to contain environmental harm through monitoring, the government faces a monitoring cost, $m \in [0, \infty)$. The monitoring expenditure depends on the effort level, e. The government has information on the financial wealth, a, of the agents and can undertake different monitoring levels for the two types of agents. Denote the monitoring expenditure $m(e)$, where e is the total effort, equal to the sum of effort exerted on rich and poor agents, $e = e_R + ne_P$, where e_i denotes the effort per individual type of agent, $i = P, R$. We assume $m_e > 0$ and $m_{ee} > 0$: the government's monitoring cost increases with the level of monitoring effort at an increasing rate. Monitoring is imperfect and cannot deterministically avoid environmental harm. The monitoring effort, however, has a direct effect on the level of care chosen by the agents: governments can verify the agents' compliance with environmental regulation and correct violations. Higher levels of monitoring by the

government increase the safety level undertaken by the agents, reducing the probability of environmental harm. Analytically this can be expressed assuming that the level of care $x(e)$ is an increasing function of government's effort for each type i of agent, i.e. we assume $x_e > 0$ and $x_{ee} < 0$ for both types of agents.

Regardless of the level of monitoring undertaken ex ante, the government faces strict ex post liability for the environmental harm suffered by the population. The government can attempt to recover these compensation payments from the responsible parties through subrogation. When successful in a subrogation action, the government can obtain full recovery of L from type-R agents, but only partial recovery $a < L$ from type-P agents. Recovery through subrogation is not instantaneous: trials are lengthy and repayment occurs with a delay equal to t. Furthermore, due to the possibility of court errors, judicial outcomes are affected by some degree of uncertainty and governments can obtain a subrogation judgment against the responsible party only with probability p_S.[60]

Denote with δ the overall effectiveness of adjudication in a subrogation action, capturing the combined impact of judicial delays and court errors. The effectiveness of adjudication, δ, can be thought as decreasing in the interest rate r and the delays in adjudication, and increasing in the probability of success of the government in the subrogation p_S. In analytical terms, $\delta = \frac{p_S}{(1+r)^t}$. A perfectly effective adjudication can be observed only in the limiting case where there are no delays in adjudication $t = 0$ (repayment to the government is collected immediately), or where the responsible parties gain no financial benefit from judicial delays, $r = 0$, (zero interest rates) and where there are no judicial errors p_S=1 (repayment occurs with certainty). The dilution effect from ineffective adjudication can be reduced or eliminated by increasing the damage award in an action for subrogation to offset the discounting from judicial delays and legal uncertainty.

The objective function of the government thus becomes:

$$min_{\{e_R, e_P\}}\, m(e_R + ne_P) + z_R p\big(x(e_R)\big)[1-\delta]L \qquad (7)$$
$$+ nz_P p\big(x(e_P)\big)[L - \delta a]$$

[60] Without loss of generality, we assume that both types of agents face the same probability of court errors, $1 - p_S$.

The agent's care incentives are affected by the government's choice of ex ante monitoring and by the threat of ex post subrogation. The objective function of a representative type-R agent is:

$$max_{\{z_R, x_R\}} V(z_R) - z_R p\big(x_R(e_R)\big)\delta L - z_R x_R(e_R) \quad (8)$$

Likewise, the objective function of a representative type-P agent is:

$$max_{\{z_P, x_P\}} V(z_P) - z_P p\big(x_P(e_P)\big)\delta a - z_P x_P(e_P) \quad (9)$$

Proposition 3. *In a polluter-does-not-pay regime, the government exerts a higher level of monitoring effort on type-P agents than type-R agents:* $e_P^* > e_R^*$

Proposition 3 can easily be proven by examining the first-order conditions of the government's maximization problem. First-order conditions with respect to e_R and e_P are expressed in Equations (10) and (11), respectively:

$$m_e(e^*) = -p_x x_e(e_R^*)[1-\delta]L \quad (10)$$

$$m_e(e^*) = -p_x x_e(e_P^*)[L-\delta a] \quad (11)$$

These conditions suggest that the government will invest in effort for each type of agent to the point where the marginal cost of an additional unit of monitoring for each type of agent is equal to its marginal benefit given by increase in the agent's care and resulting reduction in the probability and expected cost of environmental harm.

Taking the ratio of Equations (10) and (11) and rearranging we get:

$$\frac{x_e(e_R^*)}{x_e(e_P^*)} = \frac{[L-\delta a]}{[1-\delta]L} > 1 \quad (12)$$

It can be seen that a sufficient condition for equilibrium is that $x_e(e_R^*)$ in Equation (12) is higher than $x_e(e_P^*)$: as $x_{ee} < 0$, it follows that $e_R^* < e_P^*$. This can be explained by the fact that the government's marginal return on monitoring efforts is higher for type-P agents, given the larger financial exposure that this type of agents leaves on the government. This result holds even in the ideal world of perfect adjudication, with $t = 0$ (repayment to the government is collected immediately), $p_S = 1$ (the repayment to the government is made with certainty), and $r = 0$ (zero interest rate). A higher level of monitoring for type-P agents will be observed also in the case where repayment in subrogation is increased by courts as a sort of punitive damage multiplier) to offset the effects of discount rates and uncertainty. The wedge between e_R^* and e_P^* is higher the lower is the wealth of type-P agents, a.

Proposition 4. *In a polluter-does-not-pay regime, an overshooting of incentives occurs, such that the optimal level of care chosen by type-P agents is higher than the level of care chosen by type-R agents:* $x_P^* > x_R^*$

As Equation (8) is convex, from the first-order condition for type-*R* agents, we obtain:

$$p_x\left(x_R^*(e_R^*)\right) = -\frac{1}{\delta L} \qquad (13)$$

Similarly, as Equation (9) is convex, from the first-order condition for type-*P* agents, we obtain:

$$p_x\left(x_P^*(e_P^*)\right) = -\frac{1}{\delta a} \qquad (14)$$

Note that the first-order conditions in Equations (13) and (14) differ from those in Equations (3) and (4). This is so for two reasons.

First, the care level is an increasing function of the monitoring effort of the government. Therefore, any $e_i^* > 0$ will positively affect the optimal care level x_i^* chosen in equilibrium by each representative agent i. If we interpret e_i^* as the equilibrium monitoring activity, $e_i^* > 0$ will cause a downward shift of the probability of harm $p(x)$ for any level of x.[61] This can be easily seen by taking the total differential of the first-order conditions in Equation (13) (analogous results are obtained differentiating the first-order conditions in Equation (14))

$$p_{xx}\left(x_i^*(e_i^*)\right)dx_i^* + p_x(x_i^*)x_e(e_i^*)de_i^* = 0 \;\; i = R, P \qquad (15)$$

From Equation (15), we can see that $\frac{dx_i^*}{de_i^*} = -\frac{p_x(x_i^*)x_e(e_i^*)}{p_{xx}\left(x_i^*(e_i^*)\right)} > 0$.

In addition to the possible effects of monitoring on the agents' levels of care, a second difference is given by the dilution effect caused by delays and uncertainties in the legal system: both types of agents know that if environmental harm occurs, their liability in subrogation will accrue with uncertainty (i.e. with probability p_S) and with a delay of t periods. The agents' expected liability towards the government will therefore be discounted by a factor δ compared to the case of direct liability in a polluter-pays regime. This dilution effect disappears only in the limiting case of perfect adjudication, as defined above, $\delta = 1$.

[61] The case $e_i = 0$, $i = R, P$ can be thought as collapsing to the model of no goverment intervention (as in the case of strict personal responsibility, except for the presence of the dilution effect).

Taking the ratio of the first-order conditions for type-R and type-P agents, we have:

$$\frac{p_x\left(x_R^*(e_R^*)\right)}{p_x\left(x_P^*(e_P^*)\right)} = \frac{a}{L} < 1 \qquad (16)$$

since $p_x\left(x_R^*(e_R^*)\right)$ in Equation (16) is clearly less than $p_x\left(x_P^*(e_P^*)\right)$. As $p_{xx} > 0$, it follows that $x_R^* < x_P^*$. This implies that, in a polluter-does-not-pay regime, type-P agents will undertake a higher level of care than type-R agents.

This suggests that there are two countervailing effects generated by the polluter-does-not-pay regime on agents' care. On the one hand, the government can exert some positive level of monitoring on both types of agents, inducing a possible increase in their level of care. On the other hand, the replacement of direct liability with indirect liability through subrogation can dilute care incentives. The net effect of the polluter-does-not-pay regime on each type of agents' optimal level of care, x_i^*, is therefore indeterminate. For type-P agents, the impact of monitoring is more likely to dominate the dilution from imperfect adjudication, since the advantage of imperfect adjudication is smaller for type-P agents, due to their limited liability. This can be seen in the limiting case of judgment-proof defendants (i.e., for values of $a \to 0$), for which the polluter-does-not-pay regime only creates positive effects through monitoring, with no dilution effect. These two countervailing effects are shown in Figure 1 depicting the possible effects of governmental monitoring and dilution due to imperfect adjudication on type-R agents.

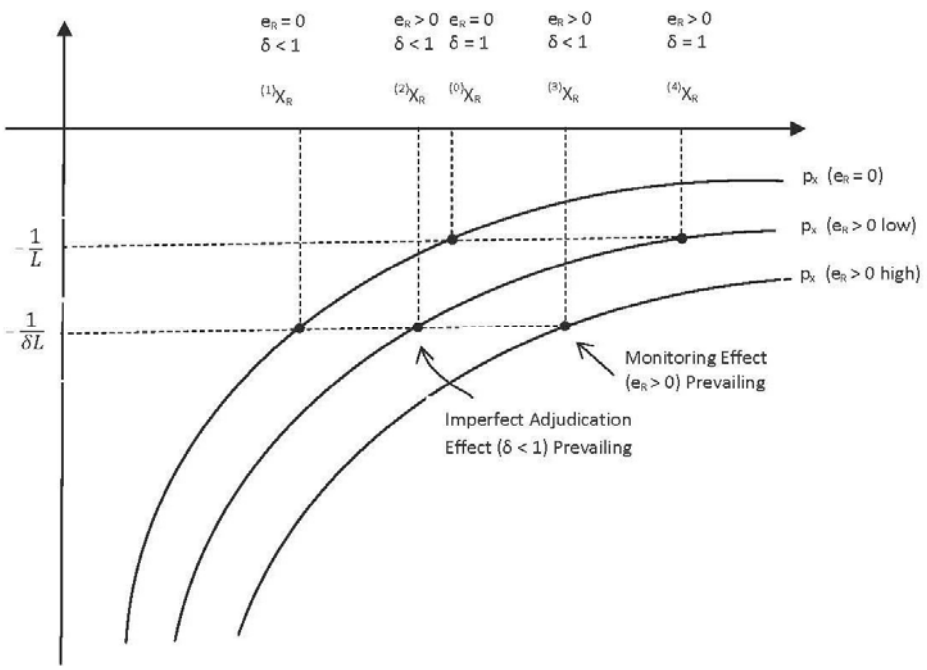

Figure 1: *Levels of Care in a Polluter-Does-Not-Pay Regime*

In Figure 1, the level of care $^{(0)}x_R$ describes the level of care that a representative type-R agent would take in a polluter-pays regime, with no monitoring ($e_R = 0$) and with perfect adjudication ($\delta = 1$). The other levels of care represent the levels of care that a type-R agent would choose in a polluter-does-not-pay regime, under different levels of monitoring and effectiveness of adjudication. Point $^{(1)}x_R$ represents the level of care that a type-R agent would undertake when the government chooses to carry out no monitoring for type-R agents, $e_R = 0$. In this case, a polluter-does-not-pay regime would have negative effects on type-R agents' level of care, given the fact that liability would accrue through subrogation, with a dilution effect due to imperfect adjudication, $\delta < 1$. Point $^{(2)}x_R$ depicts the level of care undertaken by a type-R agent when the government carries out a positive level of monitoring for type-R agents, $e_R > 0$, but where such monitoring is insufficient to compensate for the dilution from imperfect adjudication $\delta < 1$. Also in this case the care incentives created by the polluter-does-not-pay regime fall short of those obtainable through direct liability without governmental monitoring, $^{(2)}x_R < {}^{(0)}x_R$. Point $^{(3)}x_R$ depicts a similar situation

with imperfect adjudication $\delta < 1$ and positive monitoring, $e_R > 0$, where the level of care undertaken by type-R agents increases above that obtainable through direct liability, ${}^{(3)}x_R > {}^{(0)}x_R$, because of a higher level of governmental monitoring. Finally, point ${}^{(4)}x_R$ depicts a hypothetical scenario in which the government exercises positive monitoring on type-R agents, $e_R > 0$, and the government can recover in subrogation without delays and with certainty, $\delta = 1$. Here the care undertaken by type-R agents reaches its highest level, given the effects of monitoring without dilution.

A similar graphical analysis could be used to describe the effect of the polluter-does-not-pay regime on type-P agents. In this case, we would be more likely to see an improvement of the level of care through governmental monitoring, because the dilution of incentives from imperfect adjudication, $\delta < 1$, is smaller for type-P agents due to their limited financial exposure to liability, $a < L$.

We can now consider the activity level chosen in a polluter-does-not-pay regime. The activity level for type-R agents would be characterized by the following first-order condition:

$$V_z(z_R^*) = p\big(x_R^*(e_R^*)\big)\delta L + x_R^*(e_R^*) \qquad (17)$$

In analogous way, from the first-order condition of type-P agents we have:

$$V_z(z_P^*) = p\big(x_P^*(e_P^*)\big)\delta a + x_P^*(e_P^*) \qquad (18)$$

From Propositions 3 and 4 we know that $e_R^* < e_P^*$ and $x_R^* < x_P^*$. It follows that type-R agents are led to undertake lower care per unit of activity than type-P agents, hence facing a lower cost for their activity. Substituting these values in (17) and (18), we obtain an interesting result, where the polluter-does-not-pay regime induces wealthy agents to carry out higher activity levels than poor agents, $z_R^* > z_P^*$. The monitoring induced by a polluter-does-not-pay regime thus has an overshooting effect on both care and activity levels, with a higher level of care and excessive reduction of activity levels for type-P agents. In Section 4 below, we will return to these results examining in greater detail the welfare effects of these alternative liability regimes, with a systematic comparison of care levels and activity levels.

3.3 Evaluating the Two Regimes under Different Environments

We shall now carry out a comparative statics analysis to evaluate the effects of our two liability regimes under different environmental conditions. Following the convention in the torts literature, to allow for determinate signs, comparative statics will be marked assuming away second-order effects. We begin considering how care and activity levels for both type-R and type-P agents vary under the polluter-pays regime. In a polluter-pays regime, we can see that the level of care chosen by type-R agents, x_R^* is positively affected by the amount of loss L and unaffected by a, while optimal care of type-P agents, x_P^*, is unaffected by L and positively affected by the amount of his liability, a. This should not be surprising, inasmuch as the actual level of wealth, a, limits liability only for type-P agents, and amounts to a non-binding constraint for the liability of type-R agents with $a \geq L$. Symmetrically, the activity level that will be optimally chosen by wealthy agents, z_R^*, is only affected by the amount of loss L, regardless of their actual wealth. The activity level of poor agents, z_P^*, instead solely depends on their financial exposure, a, regardless of the actual environmental loss, L.

$$\frac{dx_R^*}{dL} > 0, \frac{dz_R^*}{dL} < 0, \frac{dx_P^*}{da} > 0, \frac{dz_P^*}{da} < 0$$

In a polluter-pays regime the care and activity levels of type-R and type-P agents are not affected by the level of monitoring, e, or the effectiveness of adjudication, δ, inasmuch as no monitoring or subrogation actions are envisioned under this regime.

We can now consider the comparative statics for the government's monitoring level and for the care and activity levels of type-R and type-P agents in the polluter-does-not-pay regime.

In a polluter-does-not-pay regime, the government's choice of monitoring over both types of agents is positively affected by the cost-effectiveness of monitoring, which we shall denote as μ (measured as $\mu = \frac{p_x x_e}{m_e}$) and by the size of loss L, and is negatively affected by the wealth of type-P agents, a, and by the effectiveness of adjudication, δ:

$$\frac{de_R^*}{dL} > 0, \frac{de_R^*}{da} > 0, \frac{de_R^*}{d\mu} > 0, \frac{de_R^*}{d\delta} < 0$$
$$\frac{de_P^*}{dL} > 0, \frac{de_P^*}{da} < 0, \frac{de_P^*}{d\mu} > 0, \frac{de_P^*}{d\delta} < 0$$

The levels of care optimally chosen by both type-R and type-P agents, x_R^* and x_P^*, in a polluter-does-not-pay regime are positively affected by the amount of loss L and by the cost-effectiveness of governmental monitoring, μ. This is obvious, since both L and μ increase the level of governmental monitoring, with a positive effect on the agents' level of care. The effectiveness of adjudication, δ, instead, has an indeterminate effect on the care level for both type-R and type-P agents. This is so because the effectiveness of adjudication increases the direct incentives of prospective polluters but reduces the monitoring incentives of the government, with an indeterminate impact on the level of care for both types of agents. Differences arise between the two types of agents with respect to the effect of a change in the wealth and maximum financial exposure of type-P agents, a. An increase in a has an indeterminate effect type-P agents' care, x_P^*, but a negative effect on type-R agents' care, x_R^*. The effect of a on type-P agents is indeterminate because of the countervailing effects of an increase in direct incentives and reduction in governmental monitoring. The level of care of rich agents, instead, is positively affected by the wealth level of poor agents, a, due to the reallocation of monitoring effort from one category of agents to another when the wealth level changes.

$$\frac{dx_R^*}{dL} > 0, \frac{dx_R^*}{da} > 0, \frac{dx_R^*}{d\delta} \gtreqless 0, \frac{dx_R^*}{d\mu} > 0$$

$$\frac{dx_P^*}{dL} > 0, \frac{dx_P^*}{da} \gtreqless 0, \frac{dx_P^*}{d\delta} \gtreqless 0, \frac{dx_P^*}{d\mu} > 0$$

The effects of our parameters on the activity levels of prospective polluters are indirectly driven by the changes in care levels discussed above. The activity levels of type-R and type-P agents, z_R^* and z_P^*, are therefore positively affected by the amount of loss L and by the cost-effectiveness of governmental monitoring, μ. Likewise, the effectiveness of adjudication, δ, has indeterminate effects on the agents' activity levels, while changes in a have different effects for the two types of agents (indeterminate effects on the activity level of type-P agents, z_P^*, and negative effect on the activity level of type-R agents, x_R^*).

$$\frac{dz_R^*}{dL} < 0, \frac{dz_R^*}{da} < 0, \frac{dz_R^*}{d\delta} \gtreqless 0, \frac{dx_R^*}{d\mu} < 0$$

$$\frac{dz_P^*}{dL} < 0, \frac{dz_P^*}{da} \gtreqless 0, \frac{dz_P^*}{d\delta} \gtreqless 0, \frac{dz_P^*}{d\mu} < 0$$

4. Polluter-Does-Not-Pay Principle as an Optimal Instrument for Environmental Protection?

In Section 3 above, we have examined the incentives created by the polluter-pays and the polluter-does-not-pay regimes on prospective polluters. In the following, we will build on these results to examine the comparative advantage and the welfare properties of the polluter-does-not-pay regime as an instrument of environmental control. In Section 4.1, we begin showing that the polluter-does-not-pay regime may become a preferable of environmental control in situations characterized by widespread poverty, high interest rates, and judicial delays and uncertainty. In Section 4.2, we consider the welfare properties of the polluter-does-not-pay regime, comparing its effects to those that would be induced by the action of a benevolent, welfare-maximizing government.

4.1 The Comparative Advantage of the Polluter-Does-Not-Pay Principle

In this section, we shall now consider the effects of the polluter-does-not-pay regime on the aggregate level of environmental harm. The total environmental harm in the economy is given by the sum of the expected harm caused by type-R and type-P agents. Social welfare is served by maximizing the value of the risk-creating activities at the net of environmental losses, precaution costs and monitoring costs.

In a polluter-pays regime, the social problem can thus be written as follows:

$$\max W^{PP} = V(z_R^{*PP}) + nV(z_P^{*PP}) \\ -[z_R^{*PP}p(x_R^{*PP}) + nz_P^{*PP}p(x_P^{*PP})]L - z_R^{*PP}x_R^{*PP} - nz_P^{*PP}x_P^{*PP} \tag{19}$$

In a polluter-does-not-pay regime, the social problem can similarly be written as:

$$\max W^{PNP} = V(z_R^{*PNP}) + nV(z_P^{*PNP}) - \left[z_R^{*PNP}p\left(x_R^{*PNP}(e_R^*)\right) + \right. \\ \left. + nz_P^{*PNP}p\left(x_P^{*PNP}(e_P^*)\right)\right]L - m(e_R + ne_P) - z_R^{*PNP}x_P^{*PNP} - nz_P^{*PNP}x_P^{*PNP} \tag{20}$$

In the simple model presented above the optimal choice of care level is modeled as a function of:

$$x_i^* = f(\delta, \mu, \rho) \quad i = R, P$$

where $\delta \epsilon[0,1]$ measures the effectiveness of adjudication, previously defined as $\delta = \frac{p_S}{(1+r)^t}$, $\mu \epsilon[0, \infty]$ measures the cost-effectiveness of monitoring previously defined as $\mu = \frac{p_x x_e}{m_e}$, and $\rho \epsilon[0,1]$ is a measure of the poverty level, given by the percentage of poor agents in the population times their limited wealth, defined as $\rho = n\frac{L}{a}$. These synthetic measures will be used in the following sections to compare the welfare properties of our liability regimes under different environmental conditions.

In order to understand the optimal scope of application of the polluter-does-not-pay principle for controlling environmental harm, we define an iso-welfare between the two regimes as follows:

$$W^{PP} = W^{PNP} \tag{21}$$

The iso-welfare in (21) represents combinations of parameters (δ, μ, ρ) for which the polluter-pays and polluter-does-not-pay regimes prove equally efficient in containing the total environmental loss. Figure 2 below depicts the iso-welfare function setting the comparative advantage boundaries between the polluter-pays and the polluter-does not pay regimes. The parameters δ , μ and ρ are represented respectively on the vertical, horizontal-left, and horizontal-right axes of Figure 2.

Points that fall below the sloped iso-welfare function represent combinations of our three parameters for which the polluter-pays regime proves more efficient. Points above the iso-welfare function represent, instead, combinations of parameters that render the polluter-does-not-pay regime preferable for environmental control. In all points below the iso-welfare function, the benefits of governmental monitoring are more than outweighed by the problems created by the polluter-does-not-pay regime.

In order to understand the limits and respective advantages of our two liability regimes, we can study the shape of the iso-welfare function in Equation (21) to verify how welfare changes with changes in our three parameters.

$$\frac{d\mu}{d\delta} = -\frac{W_\delta^{PNP}}{W_\mu^{PNP}} < 0$$

$$\frac{d\rho}{d\delta} = -\frac{W_\delta^{PNP}}{W_\rho^{PNP} - W_\rho^{PP}} < 0$$

$$\frac{d\mu}{d\rho} = -\frac{W_\rho^{PNP} - W_\rho^{PP}}{W_\mu^{PNP}} < 0$$

Where $W_\delta^{PNP} > 0$, $W_\mu^{PNP} > 0$, $W_\rho^{PNP} - W_\rho^{PP} > 0$ since $W_\rho^{PNP} < 0$, $W_\rho^{PP} < 0$, but the decrease (in absolute terms) of total welfare in a polluter-pays regime is higher than in a polluter does-not-pay regime.

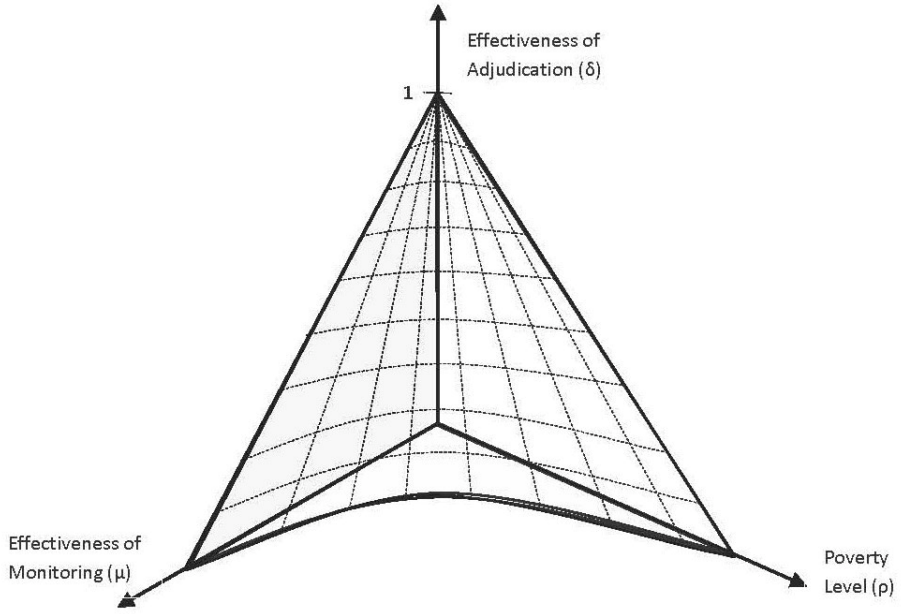

Figure 2: *The Limits of the Polluter-Pays Principle*

The intuition for these results can be explained as follows. The poverty level of prospective polluters, ρ, has a negative effect on social welfare under both liability regimes. However, the polluter-pays regime is more sensitive than the polluter-does-not-pay regime to an increase in ρ (measured by a decrease in a or an increase in L). As it can be seen by the slopes along the east-west and north-west dimensions in Figure 2, this implies that, for sufficiently large values of poverty, the polluter-does-not-pay regime may become preferable also when governments are not very effective in monitoring and/or when adjudication is imperfect and plagued with judicial delays

and uncertainty. Conversely, when adjudication becomes more reliable (points that approach the value of 1 on the vertical axis) and when monitoring becomes more effective (points that are further out on the horizontal-left axis), the adoption of the polluter-does-not-pay regime may be justified also for lower levels of poverty. Note that the parameters δ and μ do not affect total welfare in a polluter-pays regime, since government plays no role as an intermediary of liability. An increase in the effectiveness of adjudication, δ, or monitoring, μ, conversely has a positive impact on welfare in a polluter-does-not-pay regime. This implies that, other things being equal, the polluter-does-not-pay regime becomes a more desirable alternative when the effectiveness of adjudication and/or monitoring are high, especially if combined with high poverty levels. The combined presence of poverty and effective monitoring renders the polluter-does-not-pay regime especially desirable, as shown by the convexity to the origin of our sloped function.

4.2 Some Paradigmatic Cases

To illustrate the choice of liability regimes under some paradigmatic scenarios, consider the following:

Case 1: Perfect Adjudication ($\delta = 1$). According to our definition, adjudication is perfect when there are no delays in adjudication, $t = 0$ (or when there is no financial advantage associated with delays in adjudication, $r = 0$), and when there are no judicial errors, p_S=1. With perfect adjudication, there is no dilution of incentives when liability reaches the responsible parties through governmental subrogation, rather than through direct action of the victims. Comparing the first-order conditions in Equations (3) and (4) for the polluter-pays regime with Equations (13) and (14) for the polluter-does-not-pay regime, it is clear that the effect of government's monitoring dominates, i.e. $x_R^{*PNP} > x_R^{*PP}$ and $x_P^{*PNP} > x_P^{*PP}$. This implies that $p\left(x_R^{*PNP}(e_R^*)\right) < p(x_R^{*PP})$ and $p\left(x_P^{*PNP}(e_P^*)\right) < p(x_P^{*PP})$. Therefore, welfare will be increased in a polluter-does-not-pay regime, with a lower expected environmental loss. This result can be understood considering that the liability that agents face in a polluter-pays regime is not reduced by subrogation, since there is no dilution of liability through delay $t = 0$ or discount $r = 0$. Absent such dilution, the

government's monitoring has positive effects on care levels, reducing aggregate environmental harm.

Case 2: Ineffective Governmental Monitoring ($\mu = 0$). Comparing the first-order conditions in Equations (3) and (4) for the polluter-pays regime with Equations (13) and (14) for the polluter-does-not-pay regime, it is clear that in the absence of effective monitoring the dilution of incentives due to imperfect adjudication will dominate, i.e. $x_R^{*PNP} < x_R^{*PP}$ and $x_P^{*PNP} < x_P^{*PP}$. This implies that $p\left(x_R^{*PNP}(e_R^*)\right) > p(x_R^{*PP})$ and $p\left(x_P^{*PNP}(e_P^*)\right) > p(x_P^{*PP})$. Therefore the polluter-does-not-pay regime will be socially undesirable, increasing the aggregate loss from environmental harm (government monitoring imposes costs without any shift in the curve $p(x)$). Also this result can be readily understood considering that, with an ineffective governmental monitoring, the polluter-does-not-pay regime would only cause a reduction of effort for both types of agents, due to the dilution of their incentives caused by imperfect adjudication in the subrogation action.

Case 3: No Poverty ($\rho = 0$). According to our definition, there is no poverty when there is a zero fraction of prospective polluters, $n = 0$, whose wealth falls below the level of harm that they could cause, $a < L$. In this case, government will exert the same level of monitoring on both types of agent, because the agents' wealth differences do not affect their ability to repay in subrogation and are not relevant for the government's choice of monitoring effort. From an efficiency point of view, there should be no role for government when all agents have sufficient wealth to face full liability for environmental harm, $a < L$. However, governments may choose some positive level of monitoring to minimize the costs associated with the delays and uncertainties in the subrogation action.

We observe that there is no advantage in choosing a polluter-does-not-pay regime when all agents have sufficient wealth, $a \geq L$, even when there are heterogeneous values of a between types of agents. This is because wealth differences that fall above L do not affect the agents' ability to repay the government in subrogation and therefore are not relevant for the government's choice of monitoring effort. The loss to governments increases with the time necessary to recover from the responsible parties through subrogation (i.e., the higher is t) and with the interest rate r, and decreases with the probability of success in the subrogation action, p_S.

4.2 Welfare Properties of the Polluter-Does-Not-Pay Regime

We can now consider the welfare properties of the polluter-does-not-pay regime, comparing its effects to those that would be induced by the action of a benevolent, welfare-maximizing government. In order to do so, we can describe the action of a non-myopic government, choosing the optimal level of monitoring to maximize social welfare.

The objective function of a welfare-maximizing government is that of maximizing the value of the risk-creating activities, at the net of the social costs derived from environmental harm, private precaution costs, and government's monitoring costs:

$$max_{\{e_R,e_P\}} V(z_R) + nV(z_P) - \left[p\big(x(e_R)\big)z_R + np\big(x(e_P)\big)z_P\right]L - x_R z_R - nx_P z_P - m(e_R + ne_P) \tag{22}$$

The first-order conditions with respect to e_R and e_P are expressed in Equations (23) and (24), respectively:

$$m_e(e^{SO}) = \frac{dz_R}{dx_R}\frac{dx_R}{de_R}[V_Z - p(x_R)L - x_R] - z_R\frac{dx_R}{de_R}(p_x(e_R^{SO})L + 1) \tag{23}$$

$$m_e(e^{SO}) = \frac{dz_P}{dx_P}\frac{dx_P}{de_P}[V_Z - p(x_P)L - x_P] - z_P\frac{dx_P}{de_P}(p_x(e_P^{SO})L + 1) \tag{24}$$

The government assumes that both types of agents will react to governmental monitoring by adopting care and activity levels that satisfy the first-order conditions in (13) and (17) for type-R, and (14) and (18) for type-P.[62]

By studying the monitoring choices of the benevolent government, we can unveil some of the shortcomings of the polluter-does-not-pay regime, as explained in the following propositions.

Proposition 5. *In a polluter-does-not-pay regime, the government exerts lower [higher] monitoring efforts than those that would be chosen by a welfare-maximizing government for type-P [type-R] agents:* $e_R^{SO} > e_R^*$ *and* $e_P^{SO} < e_P^*$.

[62] It should be noted that also under a benevolent government action, the choice of care for type-*R* and type-*P* agents remains second-best efficient due to the dilution effect caused by an ineffective legal system.

From inspection of (15), (17) and (18) $\frac{dx_i}{de_i} = \frac{-p_x x_e}{p_{xx}} > 0$, $\frac{dz_R}{dx_R} = \frac{p_x \delta L + 1}{V_{zz}}$ and $\frac{dz_P}{dx_P} = \frac{p_x \delta a + 1}{V_{zz}}$.[63] The discrepancy between the level of monitoring exercised in a polluter-does-not-pay regime in (17) and (18) and the level that would be adopted by a benevolent welfare-maximizing government in (23) and (24) is due to the effect of imperfect adjudication: monitoring in (17) and (18) is higher than socially efficient, due to the higher financial exposure of the government when type-*P* agents are involved.

This can be seen from (13) at the optimal point, observing that right-hand side in (23) is higher than right-hand side in (13) which implies that $e_R^{SO} > e_R^*$. Note that $[V_Z - p(x_R)L - x_R] < 0$, at the optimal activity level for type-R agent, chosen according to (17). Similarly, $[V_Z - p(x_P)L - x_P] < 0$, at optimal activity level for type-*P* agent, chosen according to (18). Symmetrically, for type-*P* agent, right-hand side in (24) is lower than right-hand side in (14) at optimal point, and this implies that $e_P^{SO} < e_P^*$.

Corollary. *In a polluter-does-not-pay regime, type-P [type-R] agents undertake a level of care that is higher [lower] than what would be chosen when monitoring is carried out by a benevolent, welfare-maximizing government:* $x_R^{SO} > x_R^*$ *and* $x_P^{SO} < x_P^*$.

This can be shown by noting that type-R agents choose the optimal level of care x_R^{SO} when (13) is evaluated at the socially optimal level of monitoring by the government, e_R^{SO}, i.e., $p_x\left(x_R^{SO}(e_R^{SO})\right) = -\frac{1}{\delta L}$. Since $e_R^{SO} > e_R^*$ it follows immediately that $x_R^{SO} > x_R^*$. Similarly, type-P agents choose the optimal level of care x_P^{SO} when (14) is evaluated at the socially optimal monitoring level, e_P^{SO}, i.e., $p_x\left(x_P^{SO}(e_P^{SO})\right) = -\frac{1}{\delta a}$. Since $e_P^{SO} < e_P^*$ it follows immediately that $x_P^{SO} < x_P^*$.

[63] The sign of $\frac{dz_R}{dx_R}$ is positive if the level of care is above the equilibrium level of care and negative in the opposite case. The same is true for $\frac{dz_P}{dx_P}$.

Proposition 6. *A welfare-maximizing government undertakes a higher level of monitoring for type-P agents than for type-R agents:* $e_P^{SO} > e_R^{SO}$. *The level of care chosen by type-P agents however is lower than the level of care chosen by type-R agents*: $x_P^{SO} < x_R^{SO}$.

This result can be shown by taking the ratio of Equations (23) and (24) and rearranging, to obtain:

$$\frac{z_R p_x(e_R^{SO})}{z_P p_x(e_P^{SO})} = \frac{[L-\delta a]}{[1-\delta]L} > 1 \qquad (25)$$

A sufficient but not necessary condition for equilibrium is that $p_x(e_R^{SO})$ in Equation (25) is lower than $p_x(e_P^{SO})$. Since $p_x < 0$ and $p_{xx} > 0$, it follows immediately that $e_R^{SO} < e_P^{SO}$. This result is analogous to the result obtained in the case of governmental monitoring in a polluter-does-not-pay regime. It can be explained by the fact that the government's marginal return on monitoring efforts is higher for type-*P* agents, given the lower care incentives that type-*P* agents have in the absence of monitoring. The government will allocate monitoring effort efficiently among poor and rich agents, so that the marginal benefit and marginal cost of effort will be equalized for both types of agent, i.e. $\frac{dx_R}{de_R} = \frac{dx_P}{de_P} = m_e$.

An interesting result is unveiled by comparing the effect of monitoring on the level of care in Propositions 4 and 6. As stated in Proposition 6, when monitoring is carried out by a welfare-maximizing government, type-*P* agents will choose a level of care that is lower than the level of care chosen by type-*R* agents: $x_P^{SO} < x_R^{SO}$. This follows from the fact that $e_R^{SO} > e_P^{SO}$, given decreasing marginal benefit of effort, as shown by $\frac{d^2x_R}{d(e_R)^2} = -\frac{p_x x_{ee}}{p_{xx}} > 0$. This result runs contrary to what observed in Proposition 4 in the polluter-does-not-pay regime, where $x_R^* < x_P^*$. Governmental monitoring of type-*P* agents remains high in all cases, but the monitoring carried out by a welfare-maximizing government does not lead to the paradox observed in Proposition 4, where type-*P* agents take higher care than type-*R* agents in spite of their limited liability. A welfare-maximizing government will induce lower care levels for type-*P* agents than for type-*R* agents because the precautions of type-*P* agents are socially more costly than those of type-*R* agents. Although direct precaution costs are the same for type-*P* and type-*R* agents, the inducement of precautions for type-*P*

agents necessitate higher monitoring costs, given the reduced direct incentives they face because of their limited liability.

4.3 Summary Results

In Table 1, we summarize the results of the previous analysis evaluating the efficiency of the levels of care and governmental monitoring for type-*P* and type-*R* agents in the polluter-does-not-pay regime. We do so by comparing the levels of monitoring and care in a polluter-does-not-pay regime to those that would be induced by a benevolent government, as discussed in Section 4.2.

	Polluter-Does-Not-Pay Regime	**Benevolent Government**	**A Comparison**	
			Type-*P*	**Type-*R***
Monitoring Effort	$e_R^* < e_P^*$	$e_R^{SO} < e_P^{SO}$	$e_P^{SO} < e_P^*$	$e_R^{SO} > e_R^*$
Level of Care	$x_R^* < x_P^*$	$x_R^{SO} > x_P^{SO}$	$x_P^{SO} < x_P^*$	$x_R^{SO} > x_R^*$

Table 1: *Monitoring and Care in a Polluter-Does-Not-Pay Regime*

As intuitive, in both regimes type-*P* agents are monitored more closely than type-*R* agents. In both regimes, in fact, type-*P* agents face reduced direct incentives through liability and necessitate higher governmental monitoring. The extent of monitoring of type-*P* agents, however, differs between the two regimes, $x_P^{SO} < x_P^*$.

This brings to light an interesting effect. It is possible to see that in the polluter-does-not-pay regime governmental monitoring leads to an overshooting in care incentives, actually leading type-*P* agents to adopt higher levels of care than type-*R* agents, $x_R^* < x_P^*$. This overshooting effect is not observed under a benevolent government, $x_R^{SO} > x_P^{SO}$. The reason for this overshooting effect is that in the polluter-does-not-pay regime, local governments choose a level of monitoring that minimizes the financial exposure of the local government in the face of potentially insolvent agents, without internalizing the cost that type-*P* agents face in terms of care and reduced activity levels. A benevolent government, instead, undertakes a level of monitoring that internalizes the costs as well as the benefits of the agents' care.

These results shed light on some possible policy issues for the adoption of the polluter-does-not-pay regime. A first point concerns the best institutional allocation of oversight powers for the monitoring of prospective polluters under the polluter-does-not-pay regime. The private and social value of the risk-creating activities is generally opaque to courts and governmental agencies. For this reason, these values do not generally play a direct role in tort law. In the absence of a well-functioning liability system, however, when care incentives are driven by governmental monitoring, the evaluation of the private and social value of the risk-creating activity becomes relevant. The polluter-does-not-pay regime does not create immediate incentives on the government to take into account the value of the risk-creating activity when choosing monitoring level. As we have seen, this may lead to a myopic governmental action that leads to an excessive monitoring of type-*P* and type-*R* agents. A possible way to induce monitoring agencies to consider the value of the risk-creating activities would be to facilitate a coordinated action between branches of government entrusted with environmental protection and tax revenue collection. Monitoring that distorts care and activity level incentives reduces the value and the tax-revenue potential of those activities—a cost that would be internalized and somewhat corrected through coordinated governmental action.

5. Conclusions

A number of developing countries, including India, Ecuador, Chile, Costa Rica, Kenya, among others have recently enacted legislation or developed judicial precedents that create an obligation on the state to compensate the victims of environmental harm. These judicial and legislative reinterpretations of the polluter-pays principle hold state and local governments jointly-and-severally liable for the environmental damage caused by private parties, allowing these public bodies to act in subrogation against the individual polluters when possible. These solutions are aimed at ensuring an effective and timely compensation of victims, ensuring relief even when polluters cannot be identified or are financially insolvent. In this paper, we have examined the incentives created by this regime of governmental liability on prospective polluters. We built on those results to examine the comparative advantage and the welfare properties of the polluter-pays and polluter-does-not-pay regimes as

instruments of environmental control. We have shown that polluters-do-not-pay regimes may be preferable in situations characterized by widespread poverty, high interest rates, and judicial delays and uncertainty. We further considered the welfare properties of the polluter-does-not-pay regime, comparing its effects to those that would be induced by the action of a benevolent, welfare-maximizing government. The polluter-does-not-pay regime may lead local governments to act myopically, choosing a level of monitoring that minimizes the financial exposure of the local government but does not fully internalize the costs as well as the benefits of the agents' care. The study of the advantages and the limits of these alternative instruments of environmental liability provide a valuable viewpoint to understand the interaction between legal remedies and institutional solutions for the environmental protection in developing countries.

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