http://dx.doi.org/10.18623/rvd.v23.n1.4143

HISTORICAL ASPECTS OF THE ECONOMIC FOUNDATIONS OF CONTEMPORARY ENVIRONMENTAL LAW

ASPECTOS HISTÓRICOS DOS FUNDAMENTOS ECONÔMICOS DO DIREITO AMBIENTAL CONTEMPORÂNEO

Article received on: 8/29/2025
Article accepted on: 11/28/2025

Constantinos Challoumis*
*Philips University, Athens, Greece
Orcid: https://orcid.org/0000-0002-7436-0506
challoumis_constantinos@philips.uni.ac.cy

Nikolaos Eriotis**
**National and Kapodistrian Univerity of Athens, Athens, Greece
neriot@ba.uoa.gr

Dimitrios Vasiliou**
**National and Kapodistrian Univerity of Athens, Athens, Greece
dvasiliou@ba.uoa.gr

The authors declare that there is no conflict of interest

Abstract
Contemporary environmental law is deeply embedded in economic theory, particularly in the analysis of market failures, welfare optimization, and institutional design. This study examines the economic foundations of environmental law through a theoretical and analytical framework grounded in the law-and-economics tradition and institutional economics. Rather than relying on empirical data or econometric estimation, the paper adopts a conceptual approach that classifies environmental problems according to well-established categories of market failure, including negative externalities, public goods, common-pool resources, and non-market values. Building on this classification, the study evaluates the principal regulatory instruments of environmental law—command-and-control regulation, Pigouvian taxes, tradable permit systems, subsidies, and deposit-refund schemes—by examining their theoretical efficiency, incentive structures, distributional implications, and dynamic effects on innovation. Particular attention is devoted to the role of institutions and governance, emphasizing property-rights allocation, regulatory credibility, and policy stability as critical determinants of regulatory effectiveness. The analysis is complemented by conceptual visual frameworks that synthesize the alignment between economic problem structures and legal instruments. The research argues that environmental law is best understood as a hybrid system in which

Resumo
O direito ambiental contemporâneo está profundamente enraizado na teoria econômica, particularmente na análise de falhas de mercado, otimização do bem-estar e desenho institucional. Este estudo examina os fundamentos econômicos do direito ambiental por meio de uma estrutura teórica e analítica baseada na tradição do direito e da economia e na economia institucional. Em vez de se basear em dados empíricos ou estimativas econométricas, o artigo adota uma abordagem conceitual que classifica os problemas ambientais de acordo com categorias bem estabelecidas de falhas de mercado, incluindo externalidades negativas, bens públicos, recursos de uso comum e valores não mercantis. Com base nessa classificação, o estudo avalia os principais instrumentos regulatórios do direito ambiental — regulação de comando e controle, impostos pigouvianos, sistemas de licenças negociáveis, subsídios e sistemas de depósito-reembolso — examinando sua eficiência teórica, estruturas de incentivo, implicações distributivas e efeitos dinâmicos sobre a inovação. Atenção especial é dedicada ao papel das instituições e da governança, enfatizando a alocação de direitos de propriedade, a credibilidade regulatória e a estabilidade das políticas como determinantes críticos da eficácia regulatória. A análise é complementada por estruturas visuais conceituais que sintetizam o alinhamento entre as estruturas dos problemas

economic logic, legal normativity, and institutional constraints interact. Its contribution lies in offering a coherent conceptual framework that integrates economic reasoning into environmental legal analysis, thereby providing a foundation for future empirical research and policy evaluation.

Keywords: Environmental Law. Law and Economics. Market Failure. Externalities. Public Goods. Common-Pool Resources. Pigouvian Instruments.

econômicos e os instrumentos jurídicos. A pesquisa argumenta que o direito ambiental é melhor compreendido como um sistema híbrido no qual a lógica econômica, a normatividade jurídica e as restrições institucionais interagem. Sua contribuição reside em oferecer uma estrutura conceitual coerente que integra o raciocínio econômico à análise jurídica ambiental, fornecendo assim uma base para futuras pesquisas empíricas e avaliações de políticas.

Palavras-chave: *Direito Ambiental. Direito e Economia. Falhas de Mercado. Externalidades. Bens Públicos. Recursos de Uso Comum. Instrumentos Pigouvianos.*

1 INTRODUCTION

Contemporary environmental law is grounded in the theory and doctrines of economics. Environmental problems arise when the actions of individuals or firms impose losses on third parties who neither pay for nor benefit from these actions. Bain's economics textbooks explain the need for government intervention whenever markets fail to allocate resources efficiently, particularly when an activity generates negative externalities or public bads, or when no property rights have been assigned to a public good or common-pool resource, such as clean air, biodiversity, or a stable climate. In these circumstances, the Pigovian solution to the externality problem – a tax on pollution or a price for the public good – minimizes the total costs generated by the external diseconomy. According to the standard neoclassical model of the economy, the role of law is to serve as a mechanism for distributing the wealth created by the market. Virtually all forms of environmental regulation, however, impose costs on production processes but do not provide financial compensation for those costs. As a result, the debate about the role of environmental law has focused on how the imposition of additional costs on firms affects market efficiency and the international competitiveness of those firms. Evidence that regulation also affects innovation, technological change, and the emergence of green growth paths has however led to a broadening of this focus. Economic interpretation is also applied to the growing volume of non-market valuation studies and their contribution to the emerging fields of environmental accounting and economics-

based analyses of judicial investigation (Perrings, 2021; Petrolia et al., 2020; Qiu et al., 2020; Rogers et al., 2015; Shao et al., 2020).

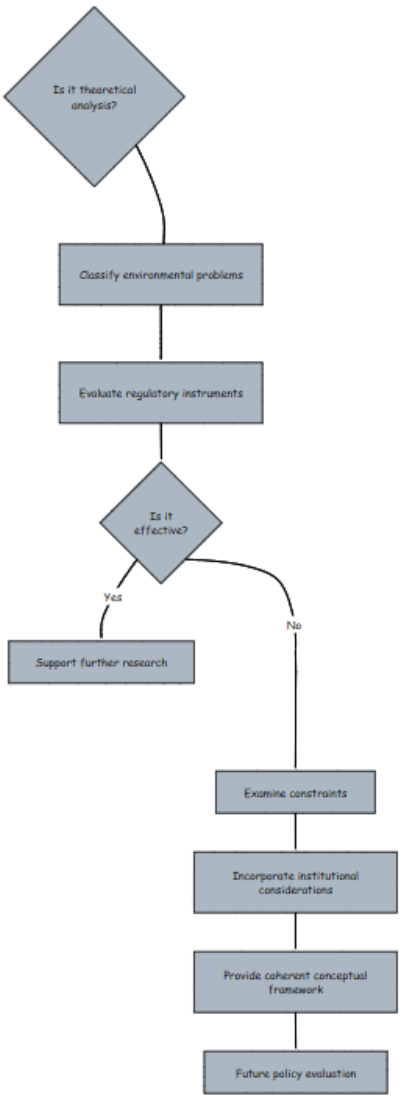
2 METHODOLOGY

This study follows a theoretical and analytical research design grounded in the law-and-economics tradition and institutional economic theory. It does not employ empirical data, econometric estimation, or case-specific measurement. Instead, the methodology is based on conceptual analysis and systematic synthesis of established economic theories relevant to environmental regulation, including externalities, public goods, common-pool resources, and non-market valuation. The aim is not to test hypotheses or establish causality, but to clarify the structural role that economic reasoning plays in the formation, justification, and evolution of environmental law. The methodological approach proceeds by first classifying environmental problems according to well-established categories of market failure. This classification provides an analytical foundation for examining why legal intervention becomes necessary in environmental contexts and how economic theory informs the scope and intensity of such intervention. Negative externalities, public goods, and common-pool resources are treated as analytically distinct, yet interrelated, economic conditions that require differentiated legal responses. Building on this classification, the study evaluates the principal instruments of environmental regulation through an economic lens. Command-and-control regulation, Pigouvian taxes, tradable permit systems, subsidies, and deposit-refund schemes are examined in terms of their theoretical efficiency, incentive structure, distributional implications, and dynamic effects on innovation and technological change. The analysis emphasizes comparative reasoning, highlighting the conditions under which particular instruments are expected to perform better or worse from an economic standpoint, without asserting empirical superiority in specific jurisdictions. The methodology further incorporates institutional and governance considerations drawn from institutional economics and public choice theory (Challoumis, 2019, 2025b). Particular attention is paid to the assignment of property rights, the credibility and stability of regulatory commitments, and the role of institutional design in shaping long-term economic behavior. This perspective allows the analysis to move beyond static efficiency considerations and to address the political and institutional constraints that influence the

effectiveness of environmental law in practice. The scope of the methodology is intentionally limited to theoretical interpretation. References to existing policy frameworks or regulatory experiences serve only illustrative and explanatory purposes. The contribution of the research lies in offering a coherent conceptual framework that integrates economic reasoning into legal analysis, thereby providing a basis for future empirical research and policy evaluation.

Figure 1

Methodological approach of economic foundations of contemporary environmental law



(Authors' scheme)

Figure 1 illustrates the methodological logic underpinning the present study and clarifies the sequential reasoning followed throughout the analysis. The process begins

with an explicit confirmation of the study's theoretical orientation, emphasizing that the analysis is grounded in conceptual reasoning rather than empirical testing. This initial step is crucial, as it defines the epistemological boundaries of the research and ensures that subsequent evaluations are interpreted as analytical judgments rather than measurements of real-world performance. Once the theoretical nature of the analysis is established, the methodology proceeds with the classification of environmental problems. This step reflects the core assumption of law-and-economics scholarship: that legal intervention is justified primarily by identifiable forms of market failure. Environmental problems are therefore categorized according to well-established economic typologies, such as negative externalities, public goods, common-pool resources, and non-market values. This classification provides the analytical foundation upon which regulatory responses can be meaningfully assessed. The next stage involves the evaluation of regulatory instruments in light of the identified market failures. Legal tools such as command-and-control regulation, Pigouvian taxation, tradable permits, subsidies, and deposit-refund schemes are examined through an economic lens, focusing on their theoretical capacity to correct inefficiencies, align incentives, and support long-term sustainability. At this point, the methodology introduces a critical decision node, asking whether a given regulatory approach can be considered effective in addressing the underlying economic problem (Challoumis, Eriotis, & Dimitrios, 2025; Challoumis, Eriotis, & Vasiliou, 2025). Where theoretical effectiveness is identified, the framework points toward supporting further research, particularly empirical or comparative studies that could test or refine the conceptual findings. Where effectiveness is uncertain or constrained, the methodological flow redirects attention toward examining constraints, including institutional limitations, political feasibility, information asymmetries, and enforcement challenges. This branching logic reflects the study's recognition that regulatory outcomes are shaped not only by economic logic but also by real-world governance conditions.

The analysis then deepens through the decomposition of institutional considerations, highlighting the role of property-rights allocation, regulatory credibility, administrative capacity, and policy stability. By explicitly incorporating these elements, the methodological framework moves beyond static efficiency analysis and acknowledges the dynamic and institutional dimensions of environmental law. This step ensures that economic reasoning is embedded within a broader legal and governance

context. The final stages of the flowchart converge on the provision of a coherent conceptual framework, which synthesizes economic theory, legal instruments, and institutional constraints into an integrated analytical structure. Rather than delivering prescriptive policy rankings, the framework serves as a guide for understanding how and why particular legal responses emerge and under what conditions they are likely to be effective. The process culminates in future policy evaluation, positioning the study as a foundation for subsequent empirical research, regulatory assessment, and interdisciplinary dialogue. Figure 1 visually encapsulates the study's methodological contribution: a structured, theory-driven approach that connects economic foundations to environmental legal design while remaining sensitive to institutional realities and policy complexity.

3 THEORETICAL FRAMEWORKS LINKING ECONOMICS AND ENVIRONMENTAL LAW

Economic theory provides a range of conceptual tools that are useful for the design and evaluation of environmental law. These tools do not provide a complete picture of the complex economic and social issues faced in environmental decision-making, yet they reflect important issues that should be incorporated into environmental law design and evaluation. The potential market failures associated with environmental resources can be conveniently classified using three main theoretical categories. The classification is adapted from economic literature on the provision of public goods, the management of common-pool resources, and the determinants of willingness to pay for non-market resources. These categories correspond closely to the answers of environmental economists to the question: "When should government intervene in environmental matters and what provisions should it put in place?" Such a question, whilst seemingly crude and naïve, exposes the critical points of-theory for the links between economics and environmental law and is appropriate for a first-level evaluation. The position that emerges is that government intervention should be based on market failure: for the three identified sources of potential market failure, environmental intervention is commonly recommended (Aruga, 2022; Cao et al., 2024; Clare et al., 2019; Duffield, 1997; Libecap, 2009; Ouyang et al., 2020; Yang et al., 2018; Zapata, 2025). The popular conceptualization of externality theory is based on a contrast between a well-functioning

competitive market and one in which a non-market externality is present. Externalities occur when one party's actions similarly affect the well-being of another party. The typical externality examined by economists is a negative externality of production in which a polluter incurs no production cost except the cost of inputs used and where the discharged effluent has a detrimental effect on the health and/or environmental quality faced by other citizens. Corresponding to these negative effects from pollution are externality impacts of production and consumption, particularly airborne and waterside emissions of Industrial waste. The presence of negative external effects warrants some government intervention that tries to internalise the external costs within the production or consumption of the polluting good or by-product.

3.1 Externalities and pigouvian interventions

Externalities, broadly defined, are situations in which an individual's actions—undertaken with little regard for the associated costs and benefits—have substantial effects on the welfare of others. Thomas C. Schelling has captured the concept with particular poignancy: "In every big city there are two noisy, smelly, irritable groups: the poor people and the rich people. When the poor people get more noise, smell, and irritation, the rich people get less, and vice versa. It is in the nature of welfare to be zero-sum." In the distinguished Scottish economist Arthur Pigou's canonical formulation, externalities occur when the private cost or benefit of a transaction diverges from the social cost or benefit, producing either overproduction or underproduction (of the externality). Schelling makes the now-familiar observation that the central problem in making decisions affecting such externalities is simply the assignment of property rights: whoever has the right to cause the externality will cause it until the marginal cost (or benefit) to him of causing it equals the marginal cost (or benefit) to the people affected by it (M. Guo et al., 2022; Z. Jiang et al., 2022; Mbanyele & Wang, 2021; Noga, 2024; Olukolajo et al., 2023; Y. Zhang et al., 2022; Zhao et al., 2024; Y. Zhou & Su, 2025). Property rights can be formally assigned through command-and-control regulation or indirectly through taxes, charges, and tradable permit systems. Such Pigouvian instruments intervene in the prices of the goods or services that produce externalities, so as to move private costs or benefits toward social costs or benefits. Environmental law that employs such instruments is, in effect, setting the external prices for those goods or

services: the prices that reflect the socially optimum trade-off between those goods or services and others. Regulation-setting such external prices can improve resource allocation, but only if the benefits of doing so exceed the costs.

3.2 Public goods and common-pool resources

Two further types of market failure—public goods and common-pool resources—are central to the justifications for much contemporary environmental regulation. Public goods are distinguished by nonexcludability and nonrivalry: individuals cannot be excluded from their consumption, and their consumption by one individual does not detract from that of others. National defence is a classic example of a public good. Because no voluntary market provision is possible, public goods are commonly provided by government and financed by the general revenue.

Many environmental assets are public goods. For example, atmospheric gases absorb the Earth's radiation and reflect heat back to space. Where the atmospheric absorption of carbon dioxide induces climate change, and where the costs of climate change are global and substantial, the regulation of atmospheric carbon dioxide emissions is justified, despite the difficult economic issues involved in appropriate design and implementation (Challoumis, 2025a). The emission of sulphur dioxide by one country has the characteristics of a public good to neighbouring countries, where airborne sulphuric acid precipitation damages forests, lakes and buildings. The rapid extinction of species may impoverish future generations, even if the current society does not wish to preserve biodiversity; hence the strong support for the sustainable-use principle of the Convention on Biological Diversity. However, the provision of many public goods is contentious. For example, while the United States has invested substantial resources in documenting the structure of the human genome, the outcome has been made freely available, with little obvious market provision. A common-pool resource is a resource system that has the characteristics of both a common property good and a common-pool resource (Guijarro & Tsinaslanidis, 2020; McCay & Jentoft, 1998; Pouw et al., 2022; Reynolds, 2019). A past example is a fishery. The direct effects of using a unit of the resource are subtractive, but the long-term effects are primarily additive. If a fishery is overharvested, it may collapse; therefore, a preventive regulation system is necessary to

avoid obtaining a common property resource. Modern examples include the carbon dioxide concentration of the atmosphere and the stratospheric ozone layer.

3.3 Wealth maximization, distributed costs, and non-market values

Adam Smith's invisible hand forms the foundation for the rationale of these two perspectives. Agreeing that society is best served when individuals pursue their self-interest, the first asks what happens when individuals pursue their self-interest but the costs of their actions are not borne by them, while the second asks what happens when individuals pursue their self-interest but the object of their actions is not privately owned. Within the second perspective, individuals are assumed to act in a manner that maximizes their own wealth, whether through production or consumption. By definition, maximization expect actions to be resource- or energy-efficient, pollution-free, and sustainable. Two distinctions exist: the relationship between wealth distribution and wealth maximization, and the distinction between material and non-material wealth. Arguments often emerge that the benefits of environmental degradation outweigh the costs. Non-market environmental values, however, play a crucial role in the wealth creation process and need to be reflected in the decision-making process. Non-market valuation techniques attempt to measure non-market environmental values. Difficulties arise in communicating the complexity of environmental values, the choice of valuation method and the choice of individuals to be interviewed, adjusted for income and other factors. Non-market values can alter the optimal solution, and the existence of a non-market valuation for an environmental asset indicates that individuals consider its optimal amount to be different from zero. The maximum willingness to pay is equivalent to a natural capital asset. Non-market environmental accounts therefore attempt to measure each nation's total wealth, which includes produced, human and natural capital. An accelerated reduction in natural capital may reduce total wealth and its return below the socially acceptable level (Atkinson et al., 2018; Joo et al., 2018; Shamshiyev, 2023; P. Zhou et al., 2023). Non-market values may also be valuable but difficult to measure accurately: Freedom of choice, bequest and existence values, for example, are also parts of an individual's wealth.

4 INSTRUMENTS OF ENVIRONMENTAL POLICY

Regulating human activity, droughts, and floods is one important role of law. It creates a legal framework that determines individuals' property rights and thus establishes patterns of production and consumption. Applying this notion to the environment results in environmental protection law. Whereas traditional legal instruments and approaches, e.g. patent and copyright laws, protect individuals' private rights, in the case of the environment legal provisions are not designed to protect the rights of individual persons, but of the public as a collective. Environmental protection law provides the necessary framework for the implementation of environmental policy designed to protect the public good called environment. The aims of environmental policy should itself be formulated in economic terms; environmental law and environmental protection complement each other. Environmental policy is concerned with ensuring that there is an optimal amount of pollution; it is about choosing the most effective means of reducing pollution. The environmental policies of many governments can be viewed as attempting to achieve these targets through traditional command-and-control technologies. Command-and-control environmental regulation often is the regulatory approach that limits personal freedom(Challoumis, 2023, 2024a). Non-economist lawyers tend to prefer this traditional method of environmental regulation that relies on rules, standards, bans, and injunctions that may be supplemented by penalties and government-administered marketable rights. By contrast, the economist's preferred regulatory choice for achieving stated environmental objectives often would be market-based instruments that internalize external costs and create choices motivated by self-interest. Non-economist lawyers perceive tax-based environmental regulations as taxing undesirable behavior. They view a gasoline tax, for example, as an additional burden on drivers, while the economist perceives it as reducing the existing incentive to pollute or as a measure to reduce the environmental damage from gasoline consumption (Bertarelli & Lodi, 2019; M. Li & Gao, 2022; X. Li et al., 2024; Mazzucato, 2023; Newbold & Johnston, 2020; Senatore et al., 2025).

4.1 Command-and-control approaches

One of the standard instruments of environmental regulation is the specification of legal standards controlling the quality of particular environmental components. These rules may be expressed in various forms—such as emission limits for hazardous air pollutants, requirements for secondary containment of oil storage facilities, or specifications of the temperature, nutrients, and pH of effluents into sensitive water bodies. Legal standards embrace also the outlawing of certain activities (e.g., the discharge of polychlorinated biphenyls into breast milk) or of specified technologies (e.g., the import of certain ozone-depleting substances). Command-and-control approaches differ in their scope and in the extent of the regulatory coverage they provide. Some are wide-ranging in application. Others are restricted to particular media or specific pollutants. A classic example of the latter is the comprehensive plan for the control of air pollution elaborated by the United States Environmental Protection Agency in accordance with the US Clean Air Act, with special provisions for major sources of hazardous air pollutants (Bateman & Kling, 2020; Drupp et al., 2017; Eubanks & Furton, 2024; Gkargkavouzi & Halkos, 2024; Reinhardt, 1999; Sagoff, 1981; Smith, 1993). The main standards formulated by the plan prescribe limits on the atmospheric concentration of particular pollutants or on the quantity of these pollutants released into the atmosphere by major sources. Standards may also be defined for other environmental variables or attributes.

4.2 Market-based instruments

Command-and-control approaches, while effective in some contexts, have important disadvantages. As administrative burdens have grown and budget constraints world-wide in many countries developed, public authorities have begun to search for policy alternatives to the traditional command-and-control model of regulatory implementationHaving conceded private market failures, these and other economists now turn theorists have become and argue that, under certain conditions, market-based instruments may offer greater efficiency than direct government regulation. These instruments can flow along three broad lines: taxes, cap-and-trade systems, and deposits and refunds (Cain et al., 2024; Dechezleprêtre & Sato, 2017; Knapp et al., 2025; Nadić,

2021; Rahim et al., 2021). They aim at harnessing the forces of wealth maximization while an underlying environmental concern; and they It is important to be aware that these instruments do not automatically generate a final outcome that is both effectively and efficient. With Pigou, they using, the very desirability of a tax in a firm level seems easily established; but must remember that a tax level the country's overall welfare depends on considerations of less and benefits, and that setting a tax at socially costliest optimum level is, as Hart point out, particularly difficult in the case of an unmarked reserved area.

4.2.1 Taxes and charges

Taxes and charges undertaking a polluter-pays principle have been among the earliest environmental policy instruments and remain an important part of the regulatory toolbox. They seek to internalize external costs by using price signals to influence behaviour. Economists typically argue that well-designed environmental taxes and charges provide relative price incentives that result in efficient environmental improvements as long as markets for the goods and services with altered relative prices are reasonably competitive. For example, a tax on carbon emissions will ideally lead to efficient reductions in carbon emissions as firms shift away from carbon-intensive inputs and consumers shift away from carbon-intensive products and consumption bundles. If simple economic theory holds, the real costs to society of undertaking the pollution abatement that these prices induce will equal the price of abating one additional unit of pollution. When markets are distorted, however, or when emissions contribute to another externality, the user charge will generally be inefficient. Market-based instruments are also attractive for reasons of institutional competence. Environmental agencies, like other regulatory agencies, often lack the capability to emulate the market's propensity to discover efficient solutions to numerous interrelated problems, given the complexity of interrelated relationships and the uncertainty about the nature of pollution abatement and technology (Challoumis & Eriotis, 2025). Environmental taxes and charges can therefore yield efficient pollution abatement at the overall societal scale even when the set of individual abatement decisions determined by these taxes and charges is itself far from efficient. For such reasons, governments often differentiate among pollutants for taxation and design a set of taxes and charges that achieves control efficiently given information constraints.

4.2.2 Tradable permits and cap-and-trade systems

Tradable permits establish a market for environmental commodities, thereby allowing entities to respond to environmental restrictions in a more flexible and economically efficient manner. First adopted in the United States to reduce acid rain and sulfur dioxide emissions from electric power generation, tradable permit schemes have since been expanded to include wastewater and odour emissions, and more recently, greenhouse gases. The European Union Emission Trading Scheme (EU ETS) introduced in 2005 is an international cap-and-trade system—the world's largest and most complex trading programme for greenhouse gases—and serves as a model for similar schemes in other countries—including, in Australia, New Zealand, and some areas of the United States and Canada. The establishment of a cap-and-trade system allows the government to undertake a partial form of wealth-maximization. By determining the aggregate level of carbon reductions required, the government reduces the total benefit of the captured resource. In turn, by allocating liability for that cost efficiently, it maximizes the wealth of all economic creatures. Thus, the cap-and-trade system reduces the economic effects of climate change while allowing the economy to minimize the costs of making that reduction. While the extent of those cost savings is often debated, the general principle of wealth maximization remains widely accepted within economic theory. In the context of climate change negotiations, it requires that any resource costs of making the reductions are minimal, thereby ensuring that the costs do not overwhelm the benefits (Y. Guo et al., 2018; Halkos & Aslanidis, 2025; J. Jiang et al., 2023; Maloney & McCormick, 1982; Michael, 2021; J. Zhang et al., 2020; Zheng et al., 2023).

4.2.3 Subsidies and deposit-refund schemes

Subsidies are direct transfers intended to stimulate environmentally-desirable activities, thereby complementing taxes that discourage undesirable activities. Banks that provide funds at lower rates for environmentally beneficial projects or schemes are examples of such market-based instruments that help achieve the policy objective of a cleaner environment. Unlike Pigovian taxes that impose a cost, subsidies are provided to encourage an environmentally-friendly act or behaviour. Deposit-refund schemes are an effective alternative to subsidies. A deposit-refund scheme entails levying a surcharge or

deposit on a harmful product, which is partially or fully refunded when the product is returned at a designated place after its purpose has been served. Interestingly, the deposit-refund scheme possesses many, if not all, the advantages of the tax. By internalizing the externalities associated with the harmful product, a deposit-refund scheme is capable of correcting environmentally damaging behaviour. The deposit acts as a Pigovian tax on those who do not return the product post-use, thus internalizing the costs involved in polluting. Deposit-refund schemes are mainly used for regulating products such as glass bottles, batteries, and cans.

4.3 Non-market valuation and environmental accounting

Valuation techniques from economics are often applied in the environmental policy arena to improve the estimation of costs and benefits, especially of non-market values. In particular, techniques for estimating the non-market value of environmental quality have been developed to meet the demand for reliable benefit estimates and to overcome adverse selection problems in the choice of policy instruments. Hedonic pricing uses variations in property and factor prices to derive implicit prices for environmental variables, contingent valuation uses survey techniques to elicit statements of willingness to pay or accept, and travel cost analysis infers values from individuals' behaviour in relation to travel to locations associated with different levels of a non-market good (Challoumis, 2024b). Non-market valuations may also be useful for environmental accounting. Recognition of the contribution of natural resources has been underway for some time. Initiatives have been taken at the national level, for example, the New Zealand Treasury's guidelines for resource balance and other environmental accounts, and also at the international level, for example, the UN System of National Accounts, Reserves Accounts established in conjunction with SNA and work by the International Geosphere-Biosphere Programme (Bateman & Kling, 2020; Cain et al., 2024; Dechezleprêtre & Sato, 2017; Drupp et al., 2017; Eubanks & Furton, 2024; Knapp et al., 2025; Nadić, 2021). The World Bank has undertaken similar studies of resource and environmental accounting and valuation in Fiji, Jamaica and other Caribbean islands. In addition to resource accounts, these initiatives have involved the estimation of the non-market value of environmental quality, in particular the avoidance of pollution and degradation.

5 ECONOMIC IMPACTS OF ENVIRONMENTAL REGULATION

Several economic issues emerge in the analysis of environmental regulation. The efficiency and distributional effects of regulation need to be assessed, as do the regulatory impacts on innovation and technological change. The role of stringent regulation at one point in time in reducing the international competitiveness of the regulated sectors is also an important consideration. Commentators have frequently linked the theory of continuous Green Protectionism with the concern that stringent regulation in one country would shift production to countries with lower standards. Regulation generates a wealth-reducing efficiency loss; it redistributes wealth from regulated to unregulated industries; it shifts investment out of the regulated sectors, especially if regulation is imposed on a country with a high capital/labour ratio; and it can even be growth-reducing. It is wide of the mark to assert, for example, that carbon taxes have only a minimal impact on GDP (J. Jiang et al., 2023; Sagoff, 1981; J. Zhang et al., 2020; Zheng et al., 2023). It is also relevant to distinguish between enabling measures that improve investment prospects in certain sectors of the economy and costly measures that reduce the overall level of investment capital. Enhanced, market-oriented regulation, such as that involving tradable permits, is likely to fall into the first category.

5.1 Efficiency and distributional effects

The relationship between environmental regulation and economic efficiency remains an ongoing source of analysis and debate among economists, policymakers, and lawyers. A well-functioning economy is characterized by the efficient allocation of resources, with marginal benefits equal to marginal costs across all economic decisions. Conventional economic analysis identifies several important criteria for efficiently achieving a given environmental goal. These include allowing different sources of a particular environmental problem to respond cost-effectively, establishing and maintaining credible property rights in the resources affected, setting standards optimally for the affected resource or focus of concern, and minimizing the cost of establishing and maintaining the regulatory framework. An important consideration in regulatory policy for any area of the economy is the distribution of costs and benefits associated with an intervention. Command-and-control regulation typically achieves its environmental

objective, but imposes compliance costs that, in turn, may have significant distributional implications. Nevertheless, the design of a well-functioning system of command-and-control regulation should seek to minimize the cost burden imposed (Bateman & Kling, 2020; Cain et al., 2024; Dechezleprêtre & Sato, 2017; Nadić, 2021). Market-based instruments are often considered more efficient than traditional forms of regulation in this context, both because they typically achieve a desired environmental outcome at lower cost and because they, in conjunction with governmental revenues, can finance general tax reductions that reduce the distortionary effects of taxes that raise revenue for government.

5.2 Innovation, technological change, and green growth

Environmental regulation may either stimulate or hinder the innovation that drives technological change and economic growth. Some firms welcome regulatory requirements as opportunities for R&D, new product development, and the expansion of markets for clean technologies, while others fear that they will divert resources and attention away from innovation. When innovation occurs, the resulting technological breakthrough typically creates a competitive advantage that increases market share and profits. When innovation lags behind the changing environment, however, the cost of compliance may contribute to business closures and declining profits in heavily regulated sectors. Economic theory suggests that governments may develop new sources of comparative advantage by investing in human capital and offering targeted support for learning and innovation(Bateman & Kling, 2020; Cain et al., 2024; Dechezleprêtre & Sato, 2017; Nadić, 2021). Such investments are especially important in the industries that stand to benefit most from environmental regulation—for example, the development of low-emission vehicles and alternative sources of energy in response to climate change policies. In this context, government intervention accompanies and supports market-led investment, thereby enhancing prospects for so-called "green growth."

5.3 International competitiveness and leakage

The spatially uneven distribution of environmental regulation can generate competitiveness and leakage concerns. Costs imposed by more stringent standards

translate into higher production costs relative to those operating under weaker environmental regimes. If environmental quality is not sufficiently reflected in consumer preferences, less-regulated jurisdictions attract resource- and pollution-intensive activities, thereby undermining the effectiveness – and possibly even raising global costs – of their respective environmental laws. A logic similar to that of trade theory, applied to a world subject to environmental regulation, suggests that the environmental problem created by such a concern is one looking for an externality-shifting response or solution. Nevertheless, testing for leakage has proven difficult. While intuitively attractive, estimates do not identify substantial leakage in practice, for a variety of reasons, including geographic distance from less-regulated jurisdictions, properly enforced border measures, and the complexity of factoring emissions into trade considerations. Such leakage dilemmas are further mitigated if a cap-and-trade system – in principle the most rigorous measure against leakage, by transforming emission levels into a marketable commodity – is adopted globally and credibly enforced across regions.

The degree to which the formal use of trade-related devices (import tariffs or export subsidies to offset regulatory differentials) resolves competitiveness concerns and reduces leakage potential remains, however, a matter of judgment. Some commentators warn against the possible use of trade measures to effect environmental ends, on the grounds of their inefficiency from a global welfare viewpoint and their potential to waken old slumbering engines of modern trade conflict – a feeling painfully sharpened by experience with preferences in a non-globalized yet politically fragile trading regime (Drupp et al., 2017; Eubanks & Furton, 2024; Rahim et al., 2021; Sagoff, 1981). Others take a different view, suggesting that trade measures might provide not merely the only external remedy adequate to an environmental problem of such a type, but also the best solution.

6 INSTITUTIONS, GOVERNANCE, AND THE DESIGN OF ENVIRONMENTAL LAW

A complete and precise analysis of the economic foundations of environmental law would consider not only the types of instruments used to address environmental issues, but also the institutional arrangements that determine the implementation of those instruments. Economics recognizes that the allocation of resources among competing

ends is inherently a problem of choice under conditions of scarcity. In a world of scarce resources, resources put to their most valued use help maximize human welfare. When governments intervene to influence the allocation of resources, they introduce their own set of costs and distortions into the economy. Environmental law is no exception, although the way in which such costs are analyzed and incorporated into the design of environmental law and institutions often differs from standard economic practice. Indeed, when economic theory and evidence are integrated into the analysis of institutions and governance systems, they can help improve the design of environmental law. Specific issues which arise in this context include the assignment of property rights, the creation of appropriate commons governance systems, and the maintenance of the credibility of environmental regulation. Environmental policy is much more than the choice of command-and-control versus market-based instruments (Atkinson et al., 2018; Bertarelli & Lodi, 2019; Guijarro & Tsinaslanidis, 2020; Joo et al., 2018; Shamshiyev, 2023; P. Zhou et al., 2023). The credibility of the policy — especially over the time frame required to address problems such as climate change, loss of biodiversity, and declining water quality and quantity — is also crucially important. People respond not only to the current incentives created by environmental policy, but also to the credible promises offered by governments.

6.1 Property rights, commons governance, and institutional arrangements

The assignment of property rights affects the degree of exploitation of common-pool resources. The classical case is the fishery, where a limited number of biologically-supported fish can be harvested. When access is unregulated, fishing reduces the yield per boat, since all fishermen exhaust the fish more rapidly, creating incentives to overfish the resource. Thus, the yield per boat falls below the maximum-sustainable-yield per boat. Allocation of fishing rights to a limited number of boats changes incentives, since the reduced number of boats increases the fish available to each boat. Other cases of successful law-institution matching for common-pool resources tend to involve not simply restrictions that limit or separate exploiters, but institutional arrangements providing de facto property rights to common-pool resources. The assignment of stable property rights can resolve dilemmas involving public goods. Governance systems for use of common-pool resources, forests, fish, aquifers, etc-capable not simply of

restricting access but also of conferring rights of use on a controlling group, remain relatively rare in developing countries. Where these exist (often serving as the own government representation for sites under threat), a low capital, low income economy may nevertheless avert the tragedy of the commons, or, as a matter of course mandate that it be formally set in the constitution (M. Li & Gao, 2022; Mazzucato, 2023; Newbold & Johnston, 2020; Senatore et al., 2025). Local common-law systems in such areas will be enshrined preserving the customary, reward the respective brokering efforts at legislation and confer credits for insurance to those partners in production who contribute to externally climate-stable environments.

6.2 Regulatory credibility, preference stability, and policy path dependency

Regulatory commitments are critical in circumstances where investments are lumpy and relationships are specific, as when polluting activities are subject to an ongoing permit and require substantial planning, finance, or technology to initiate or change. Parties devote resources to the activity on the assumption that the regulation will not be drastically changed. Changes in regulation that cause a re-evaluation of the cost-benefit balance may impose large costs on parties and possibly a reallocation of resources by creating a comparative advantage in law-sustained economy. A credible and consistent structure of regulation can therefore favor investment. The plausibility of a truthful prediction by an expert or a relevant party depends on the credibility of the regulatory institution and its political process, the nature of the regulatory environment and the sense that economic efficiency or its reflection in social welfare are important objectives. Some conditions of preference stability couple with regulatory commitment to facilitate long-term pollution-control investments (M. Guo et al., 2022; McCay & Jentoft, 1998; Noga, 2024; Pouw et al., 2022; Zhao et al., 2024). An example is the design of restrictions on the use of income tax subsidies and external payments. Other conditions give rise to policy path fluctuations that make long-term investment hazardous. An example is electoral campaigns where truths face collapse or a party announces an important effort to cancel a principal rival party measure, for instance.

6.3 Evidence and evaluation in environmental policy

For public environmental policy to advance beyond rhetoric and inertia, credible justification is needed for river basin authorities, independent pollution regulators, and the rest of the apparatus. To that end, appeals to efficiency are useful but incomplete. Three basic approaches to theory and evidence support the case. First, the implications of efficiency for resources allocated to environmental protection can be examined in combination with evidence on the factors that determine the efficient level of protection. Second, the manner in which the regulations affect the distribution of benefits and costs provides evidence on the likely political durability of regulations once adopted. Regulations that yield an exceptionally lopsided distribution of costs or benefits are particularly susceptible to political destabilization. Third, the impact of the regulations on innovation and technological change provides evidence on the longer-term impact of regulatory intervention in a dynamic setting. Some effects of environmental regulation challenge standard efficiency property and raise the question of how strongly the property-stability connection should be taken, especially in the context of decisions close to the margin. The concerns focus on the political or income distribution rather than the resource allocation ramifications of regulatory choices (Atkinson et al., 2018; Bertarelli & Lodi, 2019; Mazzucato, 2023; Shamshiyev, 2023). The particularly high costs of political reversals of regulations – the 'window of opportunity cost' – derives from the fact that regulatory change is difficult, any change is likely to favour the group exerting the strongest pressure, and many regulations involve a one-sided distribution of costs and benefits. Even a superficial examination indicates that, while the effects of regulation should not be dismissed among richer nations, the cost hypotheses about their effects are difficult to sustain in general, especially for all regulations in all countries.

7 CASE STUDIES IN CONTEMPORARY ENVIRONMENTAL LAW

Applications of contemporary environmental law provide opportunities to demonstrate how economics bears on the design and evaluation of particular laws. Consider three areas—climate change, biodiversity protection, and pollution—where economists and lawyers work closely if not always comfortably together. The economics of climate change helps delineate the goal of regulatory intervention and identifies broad,

parsimonious classes of instruments for achieving it. The study of biodiversity offers a cautionary tale about an exclusive focus on a single framework—here, public goods theory—and its implications for the choice of policy instruments. Finally, the economics of water demonstrates that a bargain-based approach to pollution control—here, the assignment of well-defined rights to pollute—can yield a reasonably efficient solution under conditions of private information (M. Li & Gao, 2022; X. Li et al., 2024; Newbold & Johnston, 2020; Senatore et al., 2025). Governments currently approach the problem of climate change by attempting to reduce emissions of greenhouse gases, seeking to stabilize concentrations in the atmosphere and thus avert potentially catastrophic shifts in climate. The underlying economics proceeds from the idea that the problem constitutes a global externality, brought about by the inability of the agents causing the externality to negotiate a solution. This focus sharply delineates the purpose of the regulation: to reduce emissions to a level consistent with the target path for atmospheric concentrations. A limited number of broad and reasonably elegant solutions then emerge, with price-based instruments—taxes and tradable permits—ranking at the top of the list and being preferred from the viewpoint of dynamic efficiency.

7.1 Climate change regulation and carbon pricing

The most pressing environmental issue of the twenty-first century is climate change. Fossil-fuel combustion and deforestation release carbon dioxide and other greenhouse gases into the atmosphere, resulting in an enhanced greenhouse effect that threatens the global climate system. The problem is characterized by several dimensions specific to climate change as opposed to environmental degradation more generally: the accumulation of climate-forcing pollutants in the atmosphere rather than a flow; the need for coordinated global action in the face of decentralized national governance and the potential for free riding; the long time horizons of climate change, both in terms of building the required scientific and technological capacity and dealing with the resulting physical impacts; and the economywide nature of mitigation, involving changes throughout the energy, industrial, transportation, building, agricultural, and forestry sectors (Atkinson et al., 2018; Bertarelli & Lodi, 2019; Shamshiyev, 2023). The theoretical literature emphasizes the need for international cooperation to address climate change because of the free-rider problem associated with the nonexcludable nature of the

atmosphere as a carbon sink. Intergovernmental Panel on Climate Change (IPCC) studies undertake cost-benefit analyses to assess the economically efficient level and pathway for reducing greenhouse gas emissions, assuming that environmental and welfare economics principles hold—the marginal costs and benefits of mitigation are equal among all nations. Based on these analyses, the IPCC recommends that global emissions peak in the first decade of the twenty-first century and decline thereafter, eventually falling to around 50 percent of 2000 levels by 2050.

7.2 Biodiversity protection and natural resource management

International biodiversity agreements recognize biodiversity loss as an urgent problem, yet the outcomes to date remain insufficient. The second assessment of the Convention on Biological Diversity reports that biodiversity continues to decline worldwide as a result of habitat loss, the overexploitation of resources, introduction of invasives, and climate change. The models typically employed in the analysis of biodiversity do not prioritize product flows, as they rely heavily on a widespread assumption of substitutability. The protection of biodiversity as such has been recognized as a prerequisite for the functioning of the ecosystems that maintain the flow of marketable goods. The analysis of these goods has often been confined to the integrity of ecosystem services, here being considered in addition to the associated risks of harm for those goods remaining outside market systems (M. Li & Gao, 2022; Newbold & Johnston, 2020; Pouw et al., 2022; Reynolds, 2019). Multiple and non-marginal risks of ecosystem failure can be considered, and at least for the most serious, it may also not be unreasonable to associate with them the market rates of pure time preference usually employed in the analysis of climate change. The dynamic trading of flows of such non-marginal common-pool risks during multi-generation economic planning is particularly attractive. The same modeling considerations may also provide options for the assessment of other economic risks associated with biologically based common-pool goods.

8 DISCUSSION

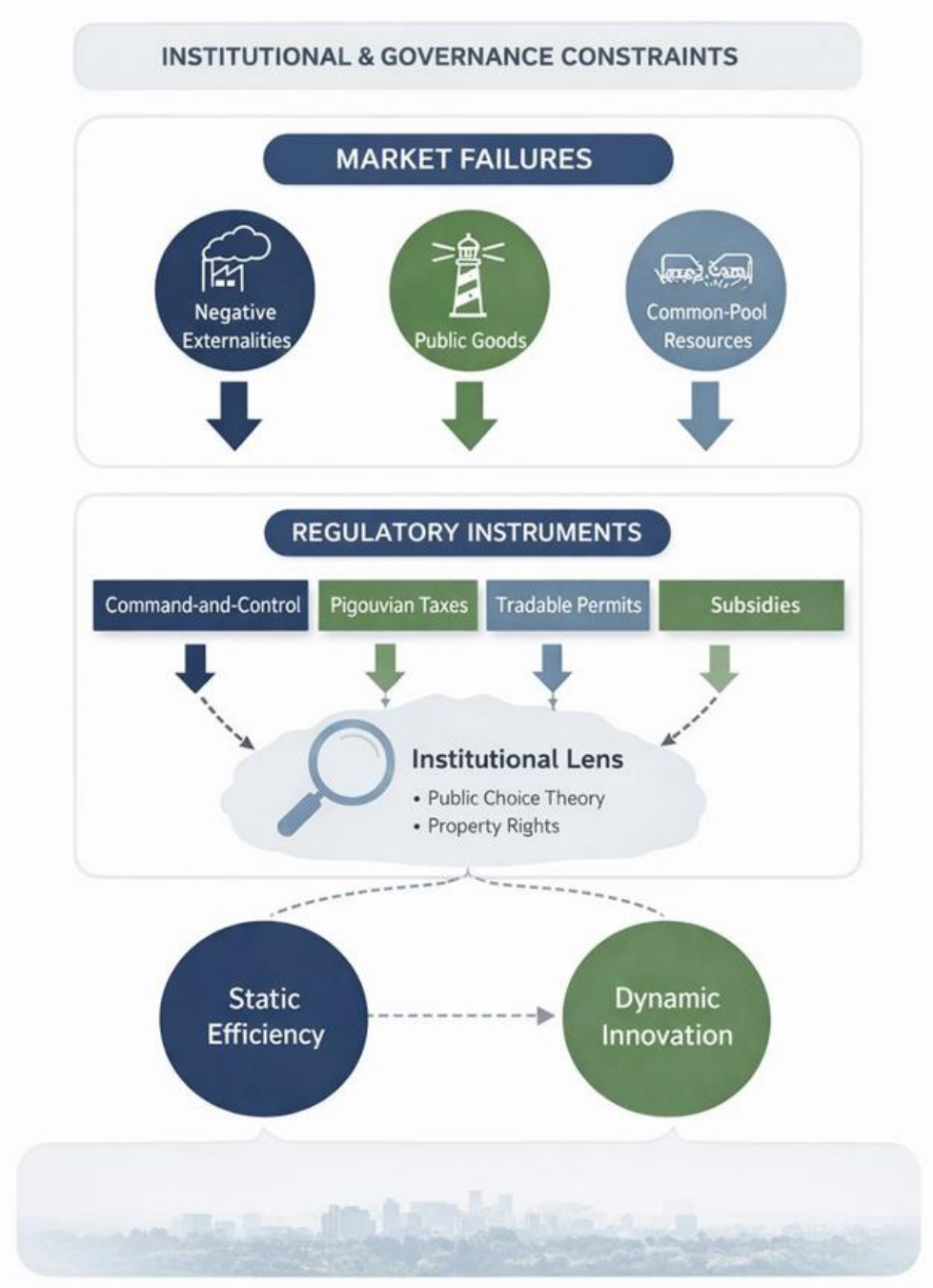
The analysis developed in this paper reinforces the view that contemporary environmental law is deeply rooted in economic reasoning, particularly in theories of

market failure, welfare optimization, and institutional design. By systematically mapping economic foundations to legal instruments, the study demonstrates that environmental regulation is not merely a normative or ethical response to environmental degradation, but a structured attempt to correct predictable failures of market allocation. The conceptual heatmap presented in Figure 1 provides a synthetic visualization of this relationship, highlighting how different legal mechanisms correspond to distinct economic problems rather than serving as universally optimal solutions. A key implication of the analysis is that instrument choice in environmental law is inherently contingent. Price-based instruments such as Pigouvian taxes and tradable permits emerge as theoretically well suited to addressing negative externalities, yet their effectiveness depends on institutional capacity, political feasibility, and informational constraints. Conversely, command-and-control regulation, often criticized from a purely economic efficiency perspective, retains a central role in the governance of public goods where exclusion and rivalry cannot be managed through market mechanisms alone. This underscores the inadequacy of dichotomous debates that frame environmental regulation as a choice between "markets versus rules," rather than as a problem of contextual alignment. The discussion also highlights the importance of institutional and governance structures, particularly in the management of common-pool resources. The strong theoretical association between such resources and property-rights or commons-governance mechanisms reflects a shift in economic thinking away from purely price-based correction toward institutional solutions that structure long-term incentives and collective behavior. Environmental law, in this sense, functions not only as a corrective tool but also as a framework for stabilizing expectations, allocating responsibilities, and maintaining regulatory credibility over time. Non-market values emerge as a particularly challenging domain for both economics and law. The analysis confirms that conventional regulatory instruments are ill-equipped to internalize values such as existence, bequest, or cultural significance. Instead, valuation and environmental accounting tools play a complementary role by expanding the informational basis of decision-making. This finding supports a broader conception of economic rationality in environmental law—one that incorporates natural capital and intergenerational considerations without reducing them entirely to market prices. Taken together, the discussion supports the conclusion that environmental law is best understood as a hybrid system, combining economic logic, legal normativity, and institutional governance. The effectiveness of this

system depends less on adherence to any single regulatory philosophy and more on the coherence between economic problem structure, legal design, and institutional context. This perspective aligns with the increasing emphasis on interdisciplinary approaches in environmental legal scholarship and policy formulation.

Figure 2

Institutional and governance constraints



(Authors' scheme, see Appendix I)

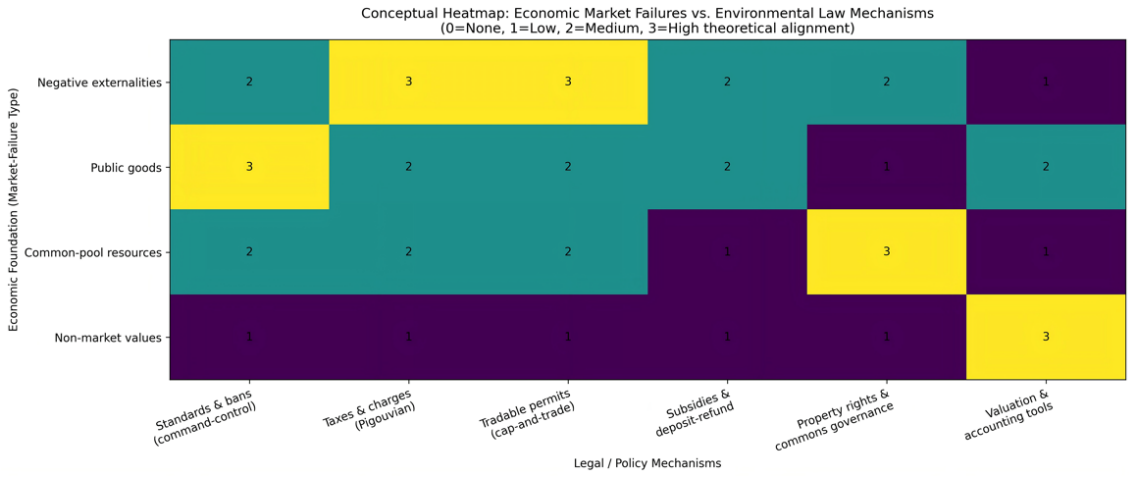
Figure 2 shows that environmental law addressing pollution control focuses principally on the prevention of harmful releases to water, land, or air, with an increasing emphasis on the introduction of measures directed toward a general improvement in environmental quality. The underlying theoretical foundation assigned to environmental pollution regulation builds primarily on the concept of externality failure. Comprehensive systems of regulation and enforcement are embraced, applying frequently detailed technical standards to specific pollutants within tightly confined geographical jurisdictions — the regulatory attempt normally ascribed as a "command-and-control" approach to environmental policy. Such an approach, however, represents only one of a number of instruments and modes of intervention available for introducing Pigouvian measures that affect an internalization of costs. The treatment of the regulation of pollution is completed by a consideration of the management of water resources. Water has its very own set of unique economic characteristics as a natural resource being both a public good and also a common-pool resource requiring a special institutional framework for both its pricing and long-term resource allocation. In this context, the so-called Coase theorem is then applied to the assignment of water rights for pollution regulation. The preservation of water quality requires the assignment of property rights to the receiving water body, that is, the river, lake, sea, or ocean — normally the domain of government regulation in the public interest. Market-based instruments also find widening application in the management of pollution through the use of tradable pollution permits. The tradeable permit system is close to a market-oriented scheme for dealing with the problem of distributing water rights among alternative users. It is combining Pigouvian price-incentives with Coasean market-based efficiency.

The interplay between theoretical understandings and practical approaches is revealed in the role of economic analysis in the reform of environmental regulation. Insights from welfare economics as well as the economising perspective on environmental law—rooted in ideas about public goods and common-pool resources, as well as the non-market values attached to clean air, water and biodiversity—have inspired successful reform for specific problems and regions. The influence of these theoretical frames is less evident in debates about the design and arrangement of regulatory regimes: here, borrowing insights from public choice theory and economic history has yielded valuable lessons. Nonetheless, progress towards the ideal of decentralised 'Pigouvian' solutions remains elusive. In general, externalities are best addressed using Pigouvian

taxation or directly negotiable solutions. Where nondiscriminatory implementation is impossible or transaction costs prohibitively high, however, a command-and-control approach remains appropriate. Addressing non-marketable public goods like climate change transfers the problem to global governance, requiring some form of carbon-price arbitrage for solution. Political pressure for global action is strong; realignment of the US economy towards carbon taxation would issue this coalition even stronger. The forces for non-market values reflected in the creation of European emissions-mitigation expenditures remain vigorously active. Yet, the path from climate obsession to action is strewn with difficulties.

Figure 3

Economic sources of market failure and the principal legal and policy



(authors' scheme, see Appendix I)

Figure 3 presents a conceptual heatmap that synthesizes the theoretical alignment between core economic sources of market failure and the principal legal and policy mechanisms used in environmental law. The figure does not represent empirical measurement but offers an interpretative visualization based on established economic theory. The intensity of each cell reflects the relative strength of theoretical correspondence between a specific market failure and a regulatory instrument, ranging from low to high alignment. The first row of the heatmap focuses on negative externalities, which exhibit strong theoretical alignment with Pigouvian taxes and tradable permit systems. This reflects the central economic proposition that price-based instruments are particularly effective in internalizing external costs by aligning private incentives with social costs. Command-and-control standards and subsidies show a

moderate correspondence, indicating their ability to reduce harmful activity, albeit often at higher administrative cost and with weaker efficiency properties. Valuation and accounting tools appear less directly aligned, as they do not themselves correct behavior but rather inform decision-making processes. The second row addresses public goods, where non-excludability and non-rivalry limit the effectiveness of pure market solutions. Here, command-and-control regulation demonstrates strong theoretical relevance, reflecting the necessity of centralized provision or regulation when voluntary market mechanisms fail. Taxes, permits, and subsidies show moderate alignment, as they may support financing or incentivizing provision but cannot fully resolve free-rider problems on their own. Valuation tools occupy a supporting role by revealing social willingness to pay, which can guide policy design without directly ensuring provision. The heatmap further illustrates that common-pool resources are most strongly associated with property-rights allocation and commons governance mechanisms. This highlights the importance of institutional design in addressing subtractability and congestion problems, where neither pure regulation nor price instruments alone are sufficient. Moderate alignment with taxes and tradable permits reflects their complementary role, while the lower relevance of subsidies and valuation tools underscores the need for enforceable governance structures rather than purely financial or informational interventions. In conclusion, non-market values display a distinctly different pattern. Their strongest association is with valuation and environmental accounting tools, reflecting the difficulty of integrating existence, bequest, and cultural values into price-based regulatory mechanisms. The uniformly low alignment with other instruments emphasizes that non-market values challenge standard wealth-maximization frameworks and require methodological extensions rather than conventional regulatory responses. Figure 3 reinforces the central argument of the paper: environmental law is most effective when legal instruments are matched to the underlying economic structure of environmental problems. The heatmap visually demonstrates that no single regulatory approach dominates across all market failures, supporting the case for a pluralistic and economically informed legal framework grounded in institutional context and governance quality.

9 CONCLUSION

Environmental law is best understood as the set of public policies designed to manage external effects, public goods, and common-pool resources. The economic debate about the optimal design of these policies is rich, varied, and evolving. Insights into when and how command-and-control measures might be ameliorated by market-based instruments are accompanied by new methodologies for valuing non-market environmental effects. Institutional concerns about the form and governance of property rights are joined by interest in the credibility of regulation, the stability of preferences, and the demand for evidence in environmental policy. In recent decades, environmental regulation has become increasingly ambitious. The management of climate change and the protection of biodiversity pose bold challenges for the global community, yet political interest often wanes. The theory linking environmental quality, economic well-being, and the wealth of nations highlights this tension. A wealth-maximization model suggests that a commitment to maintaining non-market values may be appropriate only in the presence of price-responsive preferences or dynamic complementarity.

REFERENCES

Aruga, K. (2022). Economic Instrument and Environmental Problems. *Environmental and Natural Resource Economics*. https://doi.org/10.1007/978-3-030-95077-4_2

Atkinson, G., Groom, B., Hanley, N., & Mourato, S. (2018). Environmental Valuation and Benefit-Cost Analysis in U.K. Policy. *Journal of Benefit-Cost Analysis*, *9*, 97–119. https://doi.org/10.1017/bca.2018.6

Bateman, I., & Kling, C. (2020). Revealed Preference Methods for Nonmarket Valuation: An Introduction to Best Practices. *Review of Environmental Economics and Policy*, *14*, 240–259. https://doi.org/10.1093/reep/reaa009

Bertarelli, S., & Lodi, C. (2019). Heterogeneous firms, exports and pigouvian pollution tax: Does the abatement technology matter? *Journal of Cleaner Production*. https://doi.org/10.1016/j.jclepro.2019.04.340

Cain, L., Hernández-Cortés, D., Timmins, C., & Weber, P. (2024). Recent Findings and Methodologies in Economics Research in Environmental Justice. *Review of Environmental Economics and Policy*, *18*, 116–142. https://doi.org/10.1086/728100

Cao, Y., Lin, S., Li, M., Shan, Y., & Wang, P. (2024). Green Taxes: Productivity Effects of Tax-Based Environmental Regulations on Heavily Polluting Firms. *Economic Modelling*. https://doi.org/10.1016/j.econmod.2024.106834

Challoumis, C. (2019). The R.B.Q. (Rational, Behavioral and Quantified) Model.

Ekonomika, *98*(1), 6–18. https://doi.org/10.15388/ekon.2019.1.1

Challoumis, C. (2023). FROM SAVINGS TO ESCAPE AND ENFORCEMENT SAVINGS. *Cogito*, *XV*(4), 206–216.

Challoumis, C. (2024a). From Economics to Economic Engineering (The Cycle of Money): The case of Romania. *Cogito*, *XVII*(2), 161–170.

Challoumis, C. (2024b). The Index of the Cycle of Money: The Case of Switzerland. *Journal of Risk and Financial Management*, *17*(4), 1–24. https://doi.org/https://doi.org/10.3390/jrfm17040135

Challoumis, C. (2025a). Economocracy: Global Economic Governance. *Economies*, *13*(8), 230. https://doi.org/10.3390/economies13080230

Challoumis, C. (2025b). QUANTIFICATION OF EVERYTHING METHOD IN ECONOMICS. *INDeCS*, *23*(4), 323–339. https://www.indecs.eu/2025/indecs2025-pp323-339.pdf

Challoumis, C., & Eriotis, N. (2025). The Impact of Artificial Intelligence on the Greek Economy. *Journal of Open Innovation: Technology, Market, and Complexity*, *11*(3), 1–13. https://doi.org/https://doi.org/10.1016/j.joitmc.2025.100578.

Challoumis, C., Eriotis, N., & Dimitrios, V. (2025). The Role of Pressure Groups in Greek Economic Structure. *World*, *6*(4), 150. https://doi.org/https://doi.org/10.3390/world6040150

Challoumis, C., Eriotis, N., & Vasiliou, D. (2025). Social Movements' Impact on the Greek Economy During the Financial Crisis. *Economies*, *13*(9), 269. https://doi.org/https://doi.org/10.3390/economies13090269

Clare, B., Walter, E., & Harold, E. (2019). Free market for the environment. *Economic Policy*. https://doi.org/10.18288/1994-5124-2019-1-116-125

Dechezleprêtre, A., & Sato, M. (2017). The Impacts of Environmental Regulations on Competitiveness. *Review of Environmental Economics and Policy*, *11*, 183–206. https://doi.org/10.1093/reep/rex013

Drupp, M., Meya, J., Baumgärtner, S., & Quaas, M. (2017). Economic Inequality and the Value of Nature. *PSN: Income Inequality (Topic)*. https://doi.org/10.2139/ssrn.3074570

Duffield, J. (1997). NONMARKET VALUATION AND THE COURTS: THE CASE OF THE EXXON VALDEZ. *Contemporary Economic Policy*, *15*, 98–110. https://doi.org/10.1111/j.1465-7287.1997.tb00493.x

Eubanks, L., & Furton, G. (2024). The institutional structure of pollution: large-scale externalities and the common law. *Public Choice*, *201*, 429–450. https://doi.org/10.1007/s11127-024-01172-2

Gkargkavouzi, A., & Halkos, G. (2024). The Psychology of Non-Market Environmental Valuation: An integrative review of research evidence, theoretical insights, and policy considerations. *Journal of Environmental Psychology*. https://doi.org/10.1016/j.jenvp.2024.102510

Guijarro, F., & Tsinaslanidis, P. (2020). Analysis of Academic Literature on Environmental Valuation. *International Journal of Environmental Research and Public Health*, *17*. https://doi.org/10.3390/ijerph17072386

Guo, M., Wang, H., & Kuai, Y. (2022). Environmental Policy and Green Innovation: Evidence from Heavily Polluting Firms in China. *Finance Research Letters*. https://doi.org/10.1016/j.frl.2022.103624

Guo, Y., Xia, X., Zhang, S., & Zhang, D.-N. (2018). Environmental Regulation, Government R&D Funding and Green Technology Innovation: Evidence from China Provincial Data. *Sustainability*, *10*, 1–21. https://doi.org/10.3390/su10040940

Halkos, G., & Aslanidis, P.-S. (2025). The Socio-Cultural and Spiritual Dimensions on Non-Marketed Environmental Valuation. *Sustainable Development*. https://doi.org/10.1002/sd.70178

Jiang, J., Zhang, Q.-H., & Hui, Y. (2023). The Impact of Market and Non-Market-Based Environmental Policy Instruments on Firms' Sustainable Technological Innovation: Evidence from Chinese Firms. *Sustainability*. https://doi.org/10.3390/su15054425

Jiang, Z., Xu, C., & Zhou, J. (2022). Government environmental protection subsidies, environmental tax collection, and green innovation: evidence from listed enterprises in China. *Environmental Science and Pollution Research*, *30*, 4627–4641. https://doi.org/10.1007/s11356-022-22538-3

Joo, H.-Y., Seo, Y., & Min, H. (2018). Examining the effects of government intervention on the firm's environmental and technological innovation capabilities and export performance. *International Journal of Production Research*, *56*, 6090–6111. https://doi.org/10.1080/00207543.2018.1430902

Knapp, D., Bayrle-Kelso, N., Nigg-Stock, A., & Brecht, L. (2025). The Impact of Governmental Regulations and Environmental Activities on Innovation Efficiency. *Sustainability*. https://doi.org/10.3390/su17020467

Li, M., & Gao, X. (2022). Implementation of enterprises' green technology innovation under market-based environmental regulation: An evolutionary game approach. *Journal of Environmental Management*, *308*, 114570. https://doi.org/10.1016/j.jenvman.2022.114570

Li, X., Li, M., & Zeng, H. (2024). Environmental judicial reform and corporate investment behavior - Based on a quasi-natural experiment of environmental courts. *Journal of Environmental Management*, *365*, 121640. https://doi.org/10.1016/j.jenvman.2024.121640

Libecap, G. (2009). The Tragedy of the Commons: Property Rights and Markets as Solutions to Resource and Environmental Problems. *Environmental Economics*. https://doi.org/10.1111/j.1467-8489.2007.00425.x

Maloney, M., & McCormick, R. (1982). A Positive Theory of Environmental Quality Regulation. *The Journal of Law and Economics*, *25*, 99–123. https://doi.org/10.1086/467009

Mazzucato, M. (2023). Governing the economics of the common good: from correcting market failures to shaping collective goals. *Journal of Economic Policy Reform*, *27*, 1–24. https://doi.org/10.1080/17487870.2023.2280969

Mbanyele, W., & Wang, F. (2021). Environmental regulation and technological innovation: evidence from China. *Environmental Science and Pollution Research*, *29*, 12890–12910. https://doi.org/10.1007/s11356-021-14975-3

McCay, B., & Jentoft, S. (1998). Market or Community Failure? Critical Perspectives on

Common Property Research. *Human Organization*, *57*, 21–29. https://doi.org/10.17730/humo.57.1.372712415k227u25

Michael, F. (2021). Part II Analytical Approaches, Ch.10 Economics. *The Oxford Handbook of International Environmental Law*. https://doi.org/10.1093/law/9780198849155.003.0010

Nadić, D. (2021). Understanding the public and common good in the contemporary environmental policy. *Socioloski Pregled*. https://doi.org/10.5937/socpreg55-35441

Newbold, S., & Johnston, R. (2020). Valuing non-market valuation studies using meta-analysis: A demonstration using estimates of willingness-to-pay for water quality improvements. *Journal of Environmental Economics and Management*, *104*, 102379. https://doi.org/10.1016/j.jeem.2020.102379

Noga, A. (2024). Market Solution to Environmental Tragedy with Coasean Bargaining, Commons in the Form of Common Property, and International Human Rights Law. *Groningen Journal of International Law*. https://doi.org/10.21827/grojil.11.2.230-255

Olukolajo, M., Oyetunji, A., & Amaechi, C. (2023). A Scientometric Review of Environmental Valuation Research with an Altmetric Pathway for the Future. *Environments*. https://doi.org/10.3390/environments10040058

Ouyang, X., Li, Q., & Du, K. (2020). How does environmental regulation promote technological innovations in the industrial sector? Evidence from Chinese provincial panel data. *Energy Policy*. https://doi.org/10.1016/j.enpol.2020.111310

Perrings, C. (2021). Environmental Externalities. *Conservation*. https://doi.org/10.1093/oso/9780190613600.003.0009

Petrolia, D., Guignet, D., Whitehead, J., Kent, C., Caulder, C., & Amon, K. (2020). Nonmarket Valuation in the Environmental Protection Agency's Regulatory Process. *Applied Economic Perspectives and Policy*. https://doi.org/10.1002/aepp.13106

Pouw, N., Weikard, H., & Howarth, R. (2022). Economic analysis of international environmental agreements: lessons learnt 2000–2020. *International Environmental Agreements: Politics, Law and Economics*, *22*, 279–294. https://doi.org/10.1007/s10784-022-09576-5

Qiu, L., Hu, D., & Wang, Y. (2020). How do firms achieve sustainability through green innovation under external pressures of environmental regulation and market turbulence? *Business Strategy and the Environment*. https://doi.org/10.1002/bse.2530

Rahim, N., Othman, J., Salleh, N., & Chamhuri, N. (2021). A Non-Market Valuation Approach to Environmental Cost-Benefit Analysis for Sanitary Landfill Project Appraisal. *Sustainability*. https://doi.org/10.3390/su13147718

Reinhardt, F. (1999). Market Failure and the Environmental Policies of Firms: Economic Rationales for "Beyond Compliance" Behavior. *Journal of Industrial Ecology*, *3*. https://doi.org/10.1162/108819899569368

Reynolds, J. (2019). An economic analysis of international environmental rights. *International Environmental Agreements: Politics, Law and Economics*, *19*, 557–575. https://doi.org/10.1007/s10784-019-09454-7

Rogers, A., Kragt, M., Gibson, F., Burton, M., Petersen, E., & Pannell, D. (2015). Non-Market Valuation: Usage and Impacts in Environmental Policy and Management in Australia. *Agricultural & Natural Resource Economics EJournal*. https://doi.org/10.1111/1467-8489.12031

Sagoff, M. (1981). Economic Theory and Environmental Law. *Michigan Law Review*, *79*, 1393–1420. https://doi.org/10.2307/1288102

Senatore, L., Bimonte, G., & Gatto, A. (2025). Sustainable and Resilient Governance of Common-Pool Resources: A Critical Analysis of Non-Cooperative and Cooperative Game Theory Applications. *Journal of Economic Surveys*. https://doi.org/10.1111/joes.12690

Shamshiyev, O. (2023). A Theoretical Study on Negative Externalities and the Free-Rider Problem in Natural Resource Management from Islamic Law Perspective. *İslam Ekonomisi ve Finansı Dergisi (İEFD)*. https://doi.org/10.54863/jief.1381347

Shao, S., Hu, Z., Cao, J., Yang, L., & Guan, D. (2020). Environmental Regulation and Enterprise Innovation: A Review. *Business Strategy and the Environment*. https://doi.org/10.1002/bse.2446

Smith, V. (1993). Nonmarket valuation of environmental resources: an interpretive appraisal. *Land Economics*, *69*, 1–26. https://doi.org/10.2307/3146275

Yang, Q., Liu, G., Casazza, M., Campbell, E., Giannetti, B., & Brown, M. (2018). Development of a new framework for non-monetary accounting on ecosystem services valuation. *Ecosystem Services*. https://doi.org/10.1016/j.ecoser.2018.09.006

Zapata, E. M. J. (2025). Environmental externalities, from an economic perspective. *Environmental Research and Ecotoxicity*. https://doi.org/10.56294/ere2025181

Zhang, J., Kang, L., Li, H., Ballesteros-Pérez, P., Skitmore, M., & Zuo, J. (2020). The impact of environmental regulations on urban Green innovation efficiency: The case of Xi'an. *Sustainable Cities and Society*. https://doi.org/10.1016/j.scs.2020.102123

Zhang, Y., Hu, H., Zhu, G., & You, D.-M. (2022). The impact of environmental regulation on enterprises' green innovation under the constraint of external financing: evidence from China's industrial firms. *Environmental Science and Pollution Research*, *30*, 42943–42964. https://doi.org/10.1007/s11356-022-18712-2

Zhao, A., Zhang, H., Liu, Y., & Guan, H. (2024). Environmental taxes, technological innovation and firm performance: Evidence from China's manufacturing firms. *Heliyon*, *10*. https://doi.org/10.1016/j.heliyon.2024.e31386

Zheng, Q., Li, J., & Duan, X. (2023). The Impact of Environmental Tax and R&D Tax Incentives on Green Innovation. *Sustainability*. https://doi.org/10.3390/su15097303

Zhou, P., Song, F., & Huang, X. (2023). Environmental regulations and firms' green innovations: Transforming pressure into incentives. *International Review of Financial Analysis*. https://doi.org/10.1016/j.irfa.2023.102504

Zhou, Y., & Su, Q. (2025). Environmental Protection Tax, Management Efficiency, and Enterprise Green Technology Innovation. *Finance Research Letters*. https://doi.org/10.1016/j.frl.2025.106860

APPENDIX I

```
# (C)(R) Constantinos Challoumis 2025 All Rights Reserved

import numpy as np

import matplotlib.pyplot as plt


# Conceptual heatmap values (0=none, 1=low, 2=medium, 3=high)

rows = ["Negative externalities", "Public goods", "Common-pool resources", "Non-market values"]

cols = ["Standards & bans\n(command-control)",

        "Taxes & charges\n(Pigouvian)",

        "Tradable permits\n(cap-and-trade)",

        "Subsidies &\ndeposit-refund",

        "Property rights &\ncommons governance",

        "Valuation &\naccounting tools"]


data = np.array([

    [2, 3, 3, 2, 2, 1],  # Externalities

    [3, 2, 2, 2, 1, 2],  # Public goods

    [2, 2, 2, 1, 3, 1],  # Common-pool

    [1, 1, 1, 1, 1, 3],  # Non-market values

], dtype=float)


fig, ax = plt.subplots(figsize=(14, 6))

im = ax.imshow(data, aspect='auto')
```

```
# Ticks & labels
ax.set_xticks(np.arange(len(cols)))
ax.set_yticks(np.arange(len(rows)))
ax.set_xticklabels(cols)
ax.set_yticklabels(rows)

# Rotate x labels for readability
plt.setp(ax.get_xticklabels(), rotation=20, ha="right", rotation_mode="anchor")

# Annotate cells
for i in range(data.shape[0]):
    for j in range(data.shape[1]):
        ax.text(j, i, int(data[i, j]), ha='center', va='center')

ax.set_title("Conceptual Heatmap: Economic Market Failures vs. Environmental Law Mechanisms\n"
             "(0=None, 1=Low, 2=Medium, 3=High theoretical alignment)")
ax.set_xlabel("Legal / Policy Mechanisms")
ax.set_ylabel("Economic Foundation (Market-Failure Type)")

fig.tight_layout()

png_path = "veredas_conceptual_heatmap.png"
pdf_path = "veredas_conceptual_heatmap.pdf"
```

```
plt.savefig(png_path, dpi=300)

plt.savefig(pdf_path)

plt.show()
```

Authors' Contribution

All authors contributed equally to the development of this article.

Data availability

All datasets relevant to this study's findings are fully available within the article.

How to cite this article (APA)

Challoumis, C., Eriotis, N., & Vasiliou, D. (2026). HISTORICAL ASPECTS OF THE ECONOMIC FOUNDATIONS OF CONTEMPORARY ENVIRONMENTAL LAW. *Veredas Do Direito*, 23(1), e234143. https://doi.org/10.18623/rvd.v23.n1.4143