Public Choice
https://doi.org/10.1007/s11127-023-01098-1

On the nature and structure of externalities

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Received: 30 October 2022 / Accepted: 24 July 2023

Abstract
This paper contributes to the literature on externalities and their classification by reconciling insights from transaction costs theory with James Buchanan's and Elinor Ostrom's analyses of property rights and institutional diversity. We critique the dominant Pigouvian analysis, which assumes only two forms of institutions—namely, governments and private markets—that can internalize externalities. We develop a new taxonomy of externalities that provides relevant conceptual space for a wide array of institutions that the market-versus-state dichotomy obscures. The proposed taxonomy considers two key classes of often-conflated attributes: (1) the scale of externalities, and (2) the assignability, enforceability, and tradability of property rights. This approach enriches the Coasean (transaction cost) perspective by allowing us to unbundle transaction costs in a manner that extends its applicability to nonmarket situations in which market-based transactions are either not permitted or technically infeasible. Thus, by integrating insights from two distinct Public Choice schools, we broaden the theory of externalities to not only encompass market exchanges but also to incorporate cases in which property rights are, and will remain, unclear. We conclude that institutional diversity can offer adaptable solutions to tackle medium- and large-scale externalities.

Keywords Transaction costs · Property Rights · Externalities · Institutions · Public choice

JEL Codes E02 · E58 · H41 · P5 · P16

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Published online: 31 July 2023

1 Introduction

The presence and severity of externalities are chief economic justifications presented in support of collectivizing activities. Externalities provide an individual with an economic basis for contemplating whether to enter into a "political relationship with his [one's] fellows" (Buchanan and Tullock, 1962). When private exchanges generate unpriced costs and benefits for third parties not involved in the exchanges, the standard competitive-equilibrium logic dictates that an external authority ought to intervene, typically through some form of a corrective tax (in the case of negative externalities) or subsidy (in the case of positive externalities), to internalize the externality (Meade, 1952). The external authority's effectiveness at internalizing the externality rests on its ability to accurately measure the externality, identify the affected individuals, and implement the corrective measures (Bator, 1958). However, public choice scholars have long noted that governments fall far short of meeting these standards (Buchanan & Stubblebine, 1962; Leeson & Thompson, 2021; Tullock, 1998). Moreover, they have also shown that government decisions taken to correct one externality can produce many other unanticipated externalities that can outweigh the benefits of the previous intervention (Demsetz, 1996; Trantidis, 2023; Tullock, 1998).

Public choice scholars have stressed yet another crucial point in their analyses of externalities: the existence of externalities in a given exchange situation is neither necessary nor sufficient justification for governmental intervention (Wolf, 1979). Only if the estimated total benefits of collectivizing an activity exceed the expected total costs of doing so—on account of economies of scale and bureaucratic uncertainties—can it offer a sufficient basis for collective action (Buchanan & Tullock, 1962). But this does not mean that *governments* should intervene *tout court*. Buchanan and Tullock (1962) note that the institution (for example, a market, government, or voluntary organization) that rational individuals choose to collectivize the activity depends on the relative costs of social interdependence—that is, the sum of external costs and decision-making costs (ibid., pp. 44, 46; also see Mulligan, 2023). This logic leads us to conclude that we need to compare a whole range of existing institutional arrangements—not just markets and governments—to determine the most appropriate institution to minimize interdependence costs (Ostrom, 2010). This conclusion seems straightforward. However, economists, including scholars in the public choice tradition, have largely remained immersed in the market-versus-state paradigm. This has led to contentious and often ideology-laden debates about the pitfalls of markets versus states, with one camp focusing on market failure (and hence the need for governmental intervention), and the other camp fixating on government failure (hence appealing for freer markets) (Furton & Martin, 2019). What is worse, for far too long such paradigm has permitted economists to conveniently ignore a vast array of institutional configurations—and the cooperative relationships among the institutions and organizations—that individuals across communities and cultures have devised to internalize many externalities (Ostrom, 2010; Paniagua, 2022).

Economists such as James Buchanan, Gordon Tullock, Ronald Coase, and Elinor Ostrom have advocated for a comparative analysis of alternative institutions engaged in the business of internalizing externalities (Buchanan & Tullock, 1962; Ostrom, 2011). Yet much of the contemporary scholarship, particularly within the field of economics, remains stuck in the market-versus-state dichotomy, focusing either on finding governmental interventions to

allegedly mitigate externalities or on creating de jure property rights and devising judicial reforms to decrease transaction costs by relying on markets (Medema, 2020a).

Part of the reason why economists have analyzed institutional solutions to externalities in binary terms (markets-versus-states) is that they have relied overwhelmingly on formal mathematical theorizing rather than considering externalities and institutional diversity as an analytical entry point. As a result, although various classification systems have been proposed, none have delved adequately into their intrinsic properties, interaction with the institutional environment, technology, or geography (Papandreou, 1998). In the standard Pigouvian analysis, externalities are binary phenomena. Either they are positive, to be remedied through government subsidies, or negative to be resolved through taxation. Interestingly, after the transaction cost theory's popularity rose, notably in the form of the Coase theorem proposed by George Stigler, a different kind of binary view of externalities took hold (Medema, 2020b). On the one hand are externalities with low or negligible transaction costs that can be resolved through mutual bargaining and market exchanges. On the other hand, there are externalities with prohibitive transaction costs that require external legal or political intervention (Demsetz, 1996). Thus, the dichotomization of externalities persisted, and, as a result, the profession continued to think of their institutional solutions in binary terms (Furton & Martin, 2019; Mulligan, 2023; Paniagua, 2022).

As an alternative to the dominant reductionist perspective on externalities, we offer a pragmatic, empirically grounded approach for analyzing and classifying them. We argue that there is a myriad of externality types that fall beyond the dichotomy. We build on the standard 2×2 matrix of goods based on the twin criteria of excludability and rivalrousness (Rayamajhee and Paniagua, 2021). Our points of departure are twofold: first, we focus on externalities themselves rather than on associated goods or services; second, we consider a different set of criteria for classification. Our analysis relies on two types of distinct but often-conflated attributes: (1) the scale of externalities, and (2) the assignability and enforceability of property rights. The former represents the scalar, physical feature of an externality, whereas the latter accounts for the institutional environment within which it materializes. The taxonomy of goods offers valuable insights regarding their provision through private, public, and quasi-public means. But it leaves out several factors that are vital to the discussion of externalities. A curious sidelining of the scale factor pervades most discussions regarding the typology of goods, and indirectly that of externalities. Externalities are, by definition, not private. But they can present private incentives for market entrepreneurs to innovate mechanisms to minimize external costs. Moreover, the efficacy of such solutions is highly contingent upon the scale and severity of the relevant externality. On the other hand, irrespective of their scale, excludable and rivalrous goods can be efficiently provided by a singular type of institution, namely markets. The proposed taxonomy aims to systemize and clarify these insights.

This paper contributes to public choice scholarship on externalities by mapping a way out of the market–state dichotomy by synthesizing insights from the Virginia, Bloomington, and Chicago schools on comparative institutional analysis, property rights, and transaction costs. Our main contribution to the externality debate is that we decouple the scalar (size/scale) and institutional (property rights) components of transaction costs with the goal of unraveling new properties of externalities that allow us to match an externality type with an appropriate set of governing institutions. We further provide empirical illustrations of the usefulness of the proposed taxonomy for policy analysis.

The remainder of this paper is structured as follows. Section 2 reviews different ways in which economists have conceptualized externalities. Section 3 reconciles Buchanan's, Coase's, and E. Ostrom's approaches to externalities and describes how their insights can be distinguished from the standard neoclassical approach. Section 3 then explores both the importance of transaction costs in establishing property rights, and the emphasis that Buchanan and Ostrom placed also on the scale/size of externalities in determining their relevance. By considering both scale/size and property rights factors, Sect. 4 proposes a novel taxonomy of externalities that is fitting for comparative institutional analysis. Section 4 then follows Elinor and Vincent Ostrom's (2002) plea for classifying goods and services according to their essential properties by applying their approach to the institutional configuration of externalities. Using various empirical illustrations, the paper shows that the scalar (size/scale) and institutional (assignability and enforceability of property rights) factors jointly determine the economic viability and cost-effectiveness of different solutions to externalities. Section 5 concludes.

2 Conventional classifications of externalities

Economists have been preoccupied with categorizing externalities owing to diverse motivations. Some examples of influential classifications include ones proposed by Meade (1952), Scitovsky (1954), Bator (1957), Buchanan and Stubblebine (1962), and Leeson and Rouanet (2021). One of the earliest contributions was Meade's (1952) classification, which was part of his larger project to apply theoretical tools from welfare economics to issues of trade and development (Medema, 2020b). Meade categorized externalities into two types: the "unpaid factors of production," and "atmospheric" externalities. The first type is typified by the conundrum of the apple farmer and beekeeper, in which the beekeeper benefits from the apple farmer's contribution to the production of honey but does not pay for the latter's inputs (also see Cheung, 1973). The second type occurs when the activities of one producer create an "atmosphere" favorable (or unfavorable) to the activities of other producers. Meade (1952) concluded that the latter case is more challenging because of various issues: differences in marginal valuation of the atmosphere by the favored producers, measurement issues, and coordination problems that preclude negotiations.

Bator (1957, 1958), building on Scitovsky's (1954) previous contribution, classified externalities into three different types. Bator's classification also situates the notion of externality within the broader theory of competitive equilibrium. His classification is not of externalities per se but of the ways in which the market fails because of the presence of three classes of externality: (1) ownership externalities (essentially Meade's "unpaid factors of production"), (2) technical externalities, and (3) public good externalities, which occur when goods or services are of "joint consumption nature"—that is, when the good or service enters jointly into the utility functions of multiple consumers (Bator, 1958, p. 369). In short, externalities, in Bator's classification system, are relevant to economists only because they lead to the neoclassical notion of market failure—which he defines as "the failure of more or less idealized system of price-market institutions to sustain 'desirable' activities or to stop 'undesirable' activities" (ibid., p. 351). Neither the empirical relevance of externalities and their ubiquity in all market and nonmarket exchanges, nor their intrinsic characteristics and

challenges to human welfare, are the primary motivations or the starting point of analysis for these authors' theorizing and classifications (Papandreou, 1998).

The rise of environmental economics, health economics, law & economics, and other applied subfields of economics during the 1960s brought economics down from abstract theory to specific real-world problems (Anderson & Libecap, 2014; Barzel, 1997; Paniagua, 2022). This shift generated a need to pay closer attention both to the intrinsic details of externalities and the institutions within which they are embedded. Nowhere is this empirical turn more evident than in the works of Coase (1959, 1960, 1974, 1992), which include detailed analyses of externalities ranging from railway fires and lighthouses in Great Britain to broadcasting stations in the United States. For instance, in his 1974 essay, Coase noted that although prior studies had extensively used the lighthouse example, none had taken a detailed look at the governance aspects of lighthouse operation. Lighthouses were simply "plucked out of the air to serve as an illustration", or to corroborate a conclusion derived from abstract theorizing (ibid., p. 375).

One of Coase's important insights regarding externalities is that they have a reciprocal nature (Anderson & Libecap, 2014). He turned upside down the prevailing notion that externalities are one-directional–that is, there is one party or a group of parties that causes the harm (benefit) and a different second party that receives it. According to Coase, this one-directional view ignores the very reason why party A generates an externality in the first place. Thus, precluding party A from conducting her business (or penalizing her) because it affects party B, thus B has the effect of imposing a negative externality on A. In this case, the intervening authority, rather than relying on an economically sound logic, would be making arbitrary choices regarding who the perpetrator and the victim are, which party has the property rights, and/or whose property rights to prioritize in case of overlapping claims.

For Coase (1959), when confronted with an externality situation, the economically sound choice is to "avoid the more serious harm." This entails accounting for both the value of the gains from adopting a specific solution and the value of what is sacrificed (ibid., p. 38). A prudent and efficiency-enhancing policy is one that carefully considers both the costs and benefits of available and feasible alternatives (including the status quo) and considers how they are distributed across the society (Anderson & Libecap, 2014). Thus, hastily assigning liability to one or the other party to mitigate or eliminate the problem without considering their alternative costs is economically inefficient. Coase (1960) maintained that many externalities can be successfully mitigated simply by defining and assigning property rights and lowering transaction costs, which would create conditions for interested parties to bargain with one another to achieve an efficient outcome. Coase's contributions marked a definitive turn of the externalities literature towards a focus on property rights and transaction costs (Anderson, 2004).

Although much scholarly attention has been devoted to the Coase theorem —which shows that parties can efficiently resolve externality problems if the price system is costless and property rights are well assigned—Coase (1992) himself emphasized, perhaps more forcefully, the *analytical method* that he employed to derive the theorem: comparative institutional analysis (Medema, 2020a; Pagano, 2012). From a Coasean point of view, the goal is not to seek the elusive optimality of the zero-transaction-costs world but rather to weigh costs and benefits to choose from among imperfect alternatives the mechanisms that maximizes "the value of output for the problem under consideration" (Medema, 2020a).

Unfortunately, the broader discipline ignored Coase's (1974) calls to move away from what he called the "blackboard economics" of the presumed zero-transaction-costs world and to adopt a more nuanced analysis to study both real-world externalities problems and how property rights and collective action can be fostered to mitigate them. Comparative institutional analysis, the way Coase (1992) understood it, stipulates that all institutional solutions—including both market and state solutions— are rife with transaction costs, and thus come with *institutional trade-offs* (Pagano, 2012). Hence, the preferred solution should be the one that aims at providing better governance services, on comparative grounds, while minimizing net costs, which include transaction costs (Anderson, 2004).

Had economics taken up Coase's insights, we might have avoided reclassifying externalities once again—this time along the lines of market versus state solutions—and paid closer attention to more pressing matters such as the interaction between the intrinsic attributes of specific externalities and the institutional environment (Paniagua, 2022). However, that did not happen, and economists continued to interpret Coase's (1992) central contribution as a rebuttal of the Pigouvian presumption that the responsibility for internalizing externalities rests solely with the state (Medema, 2020a, b). Hence, after Coase (1960), economists became either Pigouvians (who favored state solutions) or Coaseans (who favored market exchanges facilitated by well-assigned property rights). Demsetz (1996, p. 566), for instance, argues that Coase's main contribution was his proposal for the 'privatization' of the externality problem—via the legal creation of tradable property rights—not his broader insights on transaction costs or comparative costs.

This correct, but narrow, interpretation of Coase's works generated numerous insights regarding the previously ignored costs and limitations of state-led solutions and shifted the focus away from blackboard theorizing about externalities to examining real-world problems and legal systems (Anderson & Libecap, 2014; Cheung, 1973). A new focus was placed on the legal system, adjudication, and the role that the law plays in creating marketable property rights (Anderson, 2004; Medema, 2020a). However, this also made the intellectual discourse unnecessarily contentious, polarized, and ideology laden, thus rupturing the suture connecting the market approach, facilitated by private property rights, and the governmental regulatory approach. Many of Coase's critics conveniently ignored his emphasis on comparative institutional analysis and focused overwhelmingly on attacking the zero-transaction-cost model; they disregarded the fact that the zero-transaction-cost model is the neoclassical paradigm's interpretation by Coase, not Coase's main point of contention (Coase, 1988; Pagano, 2012). Coase's world is one of positive transaction costs. There must be a way for economists to shed this unproductive dichotomy and move the analysis of externalities forward. This is the task of the following two sections.

3 A public choice take on externalities

Where Coase's (1959, 1960, 1974) and Ostrom's (1992, 2002, 2003) approaches to externalities differ from others' is, first and foremost, in their analytical entry point. Both of their investigations into the nature and classification of externalities were firmly rooted in real-world, tangible problems; their investigations did not stem from their desire to fill logical gaps in abstract neoclassical theory. Second, both scholars were unconstrained by the methodological dogmas of their times. In lieu of mathematical modeling and abstract theorizing,

Coase conducted detailed case studies of regulatory authorities, congressional correspondence, policy proposals and bills, legal proceedings, and historical-contextual facts, and he employed the transaction cost approach to improve our understanding of actual interactions. Similarly, Ostrom used a mixed-methods approach, employing both qualitative and quantitative tools such as game theory, laboratory experiments, and analytical narratives.

Before he emigrated to the United States, Coase's primary research focus was regulated industries, including the broadcasting sector in Great Britain (Medema, 2020a). After he moved to the US, in addition to continuing his investigations of the broadcasting sector, he started studying the political economy of the Federal Communications Commission and its methods of allocating broadcast frequencies. These efforts culminated in his influential "The Federal Communications Commission" (Coase, 1959). Coase's contribution in this work has been largely interpreted as a demonstration of the superiority of the market over the state in the provision of broadcasting services. This is an important takeaway. But this interpretation glosses over his equally important institutional insight that certain legal institutions—in this case, the Federal Radio Act of 1927, which granted the commission full control over radio communication—can generate misaligned incentives resulting in the tragedy of the commons where it need not exist. Similarly, in a different article, Coase (1974) conducted a detailed analysis of several privately provided lighthouses in England from 1610 to 1675 that operated with no direct governmental help. Lighthouses charged tolls at ports and generated sufficient profits. This work challenged the conventional wisdom that government involvement is necessary to provide lighthouses.

In both studies, the intricacies of the problems—the specific details of the externalities or the collective action problems involved—formed the basis of Coase's analyses. The chosen methodological approach is comparative institutional analysis, which is neutral to governmental or private solutions but imposes a condition of symmetry for comparison (Coase, 1988). That is, actual (non-ideal) market solutions should be compared against actual (non-ideal) governmental solutions, not fictional ones (Demsetz, 1970; Wolf, 1979). Coase argues that we ought to "start our analysis with a situation approximating that which actually exists, to examine the effects of a proposed policy change and to attempt to decide whether the new situation, would be, in total, better or worse than the original one" (Coase, 1960, p. 876). Reality, not a hypothetical benchmark based on blackboard theory, should form the basis of comparing the performance of institutions.

Like Coase, Ostrom (1990) was also a proponent of comparative institutional analysis for investigating externality problems. However, unlike Coase, Ostrom only sparingly used the terms externality and transaction costs because they were not always suitable for analyzing many common-pool-resource-user communities, where local institutional norms either did not permit or outright forbade explicit transactions and actual markets. Nor do these terms fully apply to nonmarket decision-making processes at the collective-choice or constitutional level, where participants form and alter operational rules to solve social dilemmas that have a strong non-transactional or non-market emphasis (Ostrom, 2005). Although the focus of Ostrom's (1990, 2005) study was common-pool-resource (CPR) systems, she covered a broad range of collective action problems across all levels (operational, collective choice, and constitutional), including cases in which trading property rights was permissible and feasible, and cases in which it was not. Thus, Ostrom and other scholars of the Bloomington school used different terms to describe costs and challenges in CPR situations than those that would be preferred by economists studying markets and firms. For instance,

many challenges in CPR situations, such as monitoring, sanctioning, and collective-choice decision-making, would be expressed by an economist broadly in transaction cost terms.

3.1 Assignability, enforceability, and tradability of property rights

Thus far, scholarly focus has been placed overwhelmingly on the creation of formal legal and tradable private property rights as an alternative to top-down regulatory approaches to mitigating externalities (Anderson & Libecap, 2014). Simply put, the solution has been to convert non-tradable situations into tradable ones via the creation of marketable legal rights. Where that is not feasible (owing to insurmountable transaction costs), state involvement is usually called for (Libecap, 2014). The underlying assumption that motivates this dichotomous thinking is that only two forms of organization—markets and states—are relevant for resource allocation (Furton & Martin, 2019; Ostrom, 2010; Rayamajhee and Paniagua, 2021). Such dichotomous view is no longer tenable as hybrid institutions – which are neither strictly market-based nor exclusively state-managed – have become ubiquitous. Consider, for instance, the cooperative business sector in the United States, where hybrid institutions play crucial roles in the management and governance of public goods and common pool resources (Taylor, 2021). They combine the social orientation of nonprofit organizations with the for-profit organizations' capital structures and market signals, thus defying the clean distinction of the 'ideal' institutional types assumed by the market-state dichotomy. The electric cooperative sector in the US, which entails 'a confederated system of cooperatives-of-cooperatives' and relies on funding and financial management standards of modern corporations and commercial banks, provides many glaring examples of such non-ideal, hybrid models (ibid., p. 4).

We argue that the Coasean transaction cost perspective can benefit from recognizing the possibility of collective action at different levels to manage *non-tradable* property rights (Ostrom, 2012)—rights that, despite being nonexchangeable, grant the rights holders certain authority to control specific aspects of a good or resource system to varying degrees and to benefit from it. Non-tradability of property rights can arise due to legal or customary barriers. To further illustrate this point, it may be useful to recognize what Hodgson (2015a) describes as a "legal impermeability" situation—defined as a situation in which it is "too costly [or perhaps even impossible] to use the law", because the legal transaction costs are insurmountable. The idea of legal impermeability relates closely to the distinction between economic and legal property rights, as proposed by Barzel (1997). According to Barzel, legal rights are delineated and enforced by the government, whereas economic rights refer to an "individual's ability to directly consume the services of the asset, or to consume it indirectly through exchange" (ibid., p. 22). He argues that legal rights are neither necessary nor sufficient for economic rights (Barzel, 2015).

In the absence of legal rights, exchange agreements must be self-enforced to remain functional. And they are indeed likely to be self-enforced if the gains from enforcement are sufficiently greater than the costs. On the other hand, despite being endowed with legal property rights, owners may choose not to exercise their economic rights or forfeit them to the public domain if the costs of self-enforcement are too high.[1] Property rights, whether legal or economic, must be assignable and enforceable (either by the holders or rights them-

[1] The article does not concern itself with the primacy of one kind of rights over another kind. For more discussion on this topic, see Barzel (2015); Hodgson (2015b).

selves or through legal means) to be useful. However, internalizing an externality can be feasible even when property rights *are not tradeable* (Paniagua, 2022). That said, the set of possible solutions becomes smaller, because Coasean bargaining, or market-based solutions, are less likely to emerge in situations where trading of property rights is legally forbidden or is deemed socially unacceptable. Yet, participants in such situations can devise other types of hybrid and creative solutions such as unbundling of (non-tradable) property rights into separate assignable components to avoid conflicts and overcome social dilemmas (Ostrom, 2003). For example, independent veterinary clinics in the United States unbundle some elements of their property rights and voluntarily transfer partial control rights to the clinic-owned purchasing cooperative: the Veterinary Cooperative (TVC). As a result, although the ownership rights rest with the independent clinics, TVC possesses control rights to create and enforce performance standards necessary to consolidate the collective purchasing power of its member businesses. This exchange arrangement is self-enforcing because members benefit from it. Moreover, even though *de jure* control rights lie in the private domain, they are *de facto* collectivized for mutual benefit (Taylor, 2021).

Non-tradability of property rights can also be viewed as a specific case of transaction costs. Barzel (1997) defined transaction costs as "the costs associated with the transfer, capture, and protection of [property] rights," which are always positive in the real world (ibid., p. 4). The ideas of "difficulty with defining and enforcing property rights" and "non-tradable rights" overlap considerably. The former may even encompass the later. Nonetheless, we chose to disentangle property rights in this manner because many insights remain muddled due to boxing them under "transaction costs." As a result, much of recent scholarship continues to mischaracterize non-tradability situations, such as viral externalities in a pandemic, as areas entirely outside the domain of mutual bargaining and self-governance and thus as an adequate premise for external intervention (Rayamajhee, Shrestha and Paniagua, 2021).

The above analysis does not refute that Coasean bargaining, and market-based approaches are limited in their ability to internalize externalities in situations where defining, enforcing, and trading property rights are difficult. But it also opens up possibilities of other voluntary cooperative solutions that may be socially preferable and economically efficient than a uniform Pigouvian policy, even in a restricted property rights situation (Mulligan, 2023). Thus, various institutional alternatives beyond markets and states that leverage creative property rights arrangements can arise to internalize externalities whilst overcoming transactions costs hurdles (Ostrom, 2003; Schlager & Ostrom, 1992). Transaction costs determine the scale of collective action and can affect the stability of solutions. However, just one type of transaction costs, even at unsurmountable levels—for example, costs arising from nontradability of property rights—does not necessarily preclude voluntary solutions (Anderson & Hill, 1988). Thus, we argue that unbundling the notions of transaction costs into assignability, enforceability, and tradability of property rights is key to building our taxonomy.

Scholars examining common pool resources (CPRs) have considered the emergence and reconfiguration of non-tradable property rights to overcome externalities. For instance, Ostrom (1990, 2005) extended insights from the transaction costs theory to the study self-governance in non-market settings—where transactions (at least in the strictest sense of exchanging ownership rights in markets) are infeasible or impermissible, either because markets are absent or because the legal route for assigning and enforcing property rights is unavailable due to technological, geographical, or other structural reasons. According to Ostrom (1990), although legal and governmental authorities play important roles by

recognizing *de facto* institutions and, when necessary, by providing avenues for conflict resolution, the legal or governmental route is often insufficient to avoid problems posed by non-tradability. Hence, Ostrom (2005) distinguished between formal rules (*de jure* rules) and rules in use (*de facto* rules). She also showed that in many contexts, *de jure* rules and tradable property tights are not compatible with the geophysical conditions, institutional environment, features of the resource systems, and attributes of the communities (Ostrom, 1990). To circumvent this incompatibility issue, resource users devise norms and local rules (*de facto* rules) that are better suited to solve their externality and collective problems by enabling them to create non-tradable 'sets' or 'bundles of rights' and engage in collective action (Schlager & Ostrom, 1992).

Thus, Elinor Ostrom acknowledges cases in which externality problems cannot be solved by creating and enforcing *de jure* and fragmented (marketable) property rights. However, this does not mean that property rights are irrelevant—far from it, as our analysis thus far has shown. The issue is that some property rights are non-tradable and are thus a part of a wider arrangement that requires collective action or some form of governance structure at different levels (Ostrom, 2003, 2009). Often, when tradable property rights are unavailable and externalities are complex–that is, a large number of agents (individuals, organizations, authorities) organized at multiple, interconnected, and nested layers are involved, and discerning their causes and solutions are onerous–individuals create more complex institutional and governance structures to establish intricate 'bundles of rights' associated with different social positions and roles within local collective action arrangements (Ostrom, 1990, 2003; Schlager & Ostrom, 1992).

For example, in their analysis of fishery systems in Maine, Schlager and Ostrom (1992) outline five non-tradable de facto property rights–namely access rights, withdrawal rights, management rights, exclusion rights, and alienation rights–that resource users developed and implemented themselves to solve their externality problems. These rights were not designed and handed down by any regulatory agency. Nor were they economically efficient. But they were flexible enough and could be re-combined and bundled in many ways to account for local idiosyncrasies, environmental changes, and other uncertainties. Thus, using a complicated bundle of rights system, Maine fishers were able to bypass both non-tradability and nondivisibility issues (and other geographical and physical challenges) by assigning separate positions and roles (rights and responsibilities) to different individuals, and by creating new rules (permitting, requiring, or precluding different activities) to overcome collective action problems at various levels. For instance, a person who is assigned the role of an administrator of a CPR system retains the collective-choice-level right to regulate resource use (for example, regulating fishing time and the size of nets one can use to extract fish), but lacks the right to alienate the resource system. In contrast, individuals designated as resource users may only have the operational-level right to withdraw resources from a resource system as determined by operational rules. Even though no explicit forms of market transactions in an economic or legal sense take place in these instances, resource users successfully minimize monitoring costs, sanctioning costs, and decision costs to resolve their social dilemmas through self-devised mechanisms beyond the purview of markets or states. The Maine example can be viewed as one empirical illustration of a more general phenomena involving externality challenges associated with defining, enforcing, and trading property rights due to legal impermeability of customary reasons (Anderson, 2004; Barzel, 1985; Paniagua, 2022).

3.2 Size/Scale externality factors according to Ostrom and Buchanan

In addition to property rights and the transaction costs associated with them, the scale or size of the externality should be an obvious starting point in determining its policy relevance or in classifying it. The nuisance caused by one's loud neighbor is a much smaller externality than a pandemic or air pollution. Yet this scale consideration was not accounted for in Meade's, Scitovsky's, and Bator's classifications (Sect. 2). Their attention was devoted to ways in which an abstract externality enters utility and production functions and how it affects the competitive market equilibrium, disregarding its actual magnitude and impact on human welfare. To build a policy-oriented taxonomy, it seems sensible to focus on the size factor as it has direct implications for the choice of governance institutions.

Buchanan (1973) recognized the scale consideration indirectly, noting that when many parties are involved (correlated with the large size of the externality), the number of interactions required to negotiate property rights exchange rises and prevents "the emergence of tolerably efficient voluntary agreements" (ibid., p. 69). Expanding on Coase's (1960) original case of one cattle raiser and one farmer, Buchanan (1973) noted that when many cattle raisers and many farmers are involved (i.e., when the externality is large or wide-spread), inefficient results arise because of the "publicness" of interactions among farmers or the holdout power of each farmer. Here, Buchanan (1973) makes a crucial distinction between large-scale externalities (involving lengthy multilateral negotiations in a broad area) and small-size externalities (bilateral negotiations in a contained area) and suggests that institutional considerations and the scale of the externality matter for situations involving multilateral negotiations. For example, whether cattle raisers have legal rights to allow cattle to stray affects both the possibility of negotiation and the efficiency of outcomes. Indeed, in her tribute to James Buchanan, Ostrom (2011) wrote that Buchanan's (and Tullock's) insights into how size factors matter *vis-à-vis* collective action and externality were tremendously helpful in her own investigations on the capabilities and limits of citizen self-governance (ibid., p. 88). Solving large-scale externalities is challenging, primarily because organizing in large units is difficult, and even infeasible. For instance, a pandemic presents many large-scale externalities that have devastating effects on human welfare. However, given how widespread many of these externalities are, bilateral or even multilateral negotiations do not provide a promising path forward (Paniagua, 2022). Moreover, scientific uncertainties, legal and jurisdictional ambiguities prevent the assignment and implementation of tradable property rights. This leads us to a challenging situation in which neither markets nor small-scale collective action units are capable of fully mitigating the externality.

Hence, if we attempt to internalize large-scale externalities at a singular jurisdictional level, mass coordination across different layers of government and between different institutions is required. This is far more challenging than, and needs a different policy approach from, small-scale externalities with fewer coordination problems (Rayamajhee et al., 2021). Thus, large-scale externalities are large not only literally but also in a policy-coordination sense, because their effects are cross jurisdictional and along different institutional boundaries, making their governance a 'nested' challenge (Ostrom, 2012; Paniagua, 2022). These considerations regarding the scale factor led Ostrom (2009, 2012) to advance a "nested externalities" approach to address large-scale externalities such as climate change and global pandemics (see also Paniagua and Rayamajhee, 2021; Rayamajhee and Paniagua, 2022).

An additional consideration directly related to the scale factor is *non-linearity*, particularly for medium-to-large-scale externalities. Water pollution in a stream provides a good illustration. At levels that do not rise above the natural capacity of the stream to assimilate the pollutants, water pollution may not impact residents downstream. However, once the pollution breaches the assimilative capacity of the stream, it can create an effect that is "greater than the sum of its parts." This can happen for externalities characterized by increasing marginal effect functions. Moreover, joint interaction among pollutants originating from multiple sources can amplify external effects. Such features typically characterize medium to large scale, nested externalities but they tend to be absent or inconsequential for small scale externalities. For instance, nonlinearities often dominate large scale externalities, such as greenhouse gas emissions, pandemics, and nurdles (Murtazashvili et al., 2023; Paniagua, 2022); whereas for small-scale externalities, such as cattle destroying crops, linear effects are more prevalent (Buchanan, 1973, pp. 70–71).

4 A novel taxonomy of externalities

Economists have been obsessed with classifying externalities because taxonomizing helps us identify their relevant attributes and organize them in a manner that enhances our understanding (Boudreaux & Meiners, 2019; Libecap, 2014). However, if the choice of attributes is motivated by questions relating to why reality does not match an idealized world characterized by zero transaction costs and a predetermined set of institutions, the resulting analysis is unlikely to enhance our understanding (Medema, 2020b). For any analysis and classification of externalities to be useful for governance and analytical purposes, they must meet the two criteria that both Coase and Ostrom used in their works: (1) the analytical point of entry must be the externality itself and its nature, not some high-level abstract theory, and (2) reform proposals must be based on a comparison of performances across real institutional alternatives, not mythical ones.

In this section, we integrate insights from Coase, Buchanan, and Ostrom to sketch a novel taxonomy of externalities that is better suited for mapping externalities to appropriate institutional solutions. To do so, we consider the two main attributes we have identified in the previous section, namely (a) the assignability, enforceability, and tradability of property rights and (b) the size or scale factor. The former lets us acknowledge the existence of externalities involving non-tradable rights and bundles of property rights, whereas the latter allows us to account for both its policy significance and implications for collective action. These two attributes can be interpreted as different types and magnitudes of the broad notion of transaction costs—that preclude voluntary coordination or exchange (for example, see Libecap, 2014). However, the approach we put forth is to *unbundle* such abstract notion of transaction costs along its scalar (scale/size) and institutional (property rights) dimensions, because these two aspects tend to be conflated in the literature, making institutional implications of externalities a highly muddled issue.

Figure 1 presents a new taxonomy of externalities that is the focus of the remainder of this paper. On the horizontal axis, we consider the size/scale factor, ranging from small to medium to large. Following Buchanan (1973) and Ostrom and Ostrom (2002), we consider the scale/size aspect to lie on a continuum, but we divide it in three parts in the diagram

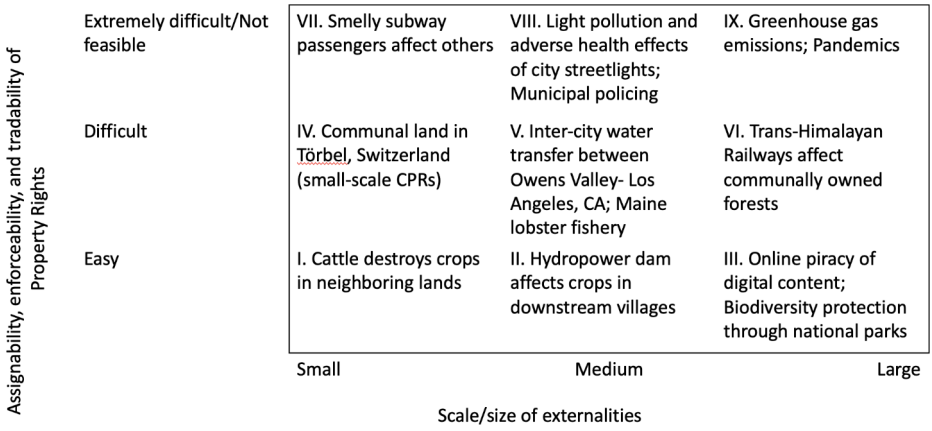

Fig. 1 A taxonomy of externalities. Source: Authors' elaboration

for illustrative purposes. On the left-hand extreme of the horizontal axis, we have small-scale externalities, either ignorable because they are of insignificant consequence or easily solvable through bilateral Coasean bargaining, market exchanges, or bilateral cooperation. On the right-hand extreme, we have large-scale externalities that require interjurisdictional coordination through diverse institutions such as complex markets, voluntary associations, governments, or other hybrid institutions (or a mix of them). In between the two extremes are medium-scale externalities, which, in many cases, can be solved via multilateral Coasean bargains (Cheung, 1973) or some form of "collective-cooperative agreement" (Buchanan, 1973). The size or scale of externalities pertains to the number of individuals, agents, or their representatives directly interacting in a given collective action situation.

On the vertical axis, we place the degree of divisibility and assignability of property rights, ranging from easy to difficult to extremely difficult or infeasible. This stems from the broader notion of transaction costs associated with defining, trading, and enforcing property rights discussed in Sect. 3. Various legal, social, technological, and geographical factors determine the level of difficulty of assigning, partitioning, and enforcing property rights: uncertainty regarding benefits and costs, heterogeneous preferences and perspectives, asymmetric information and information costs, monitoring and sanctioning mechanisms, enforcement costs, decision costs, and principal-agent problems, to list a few (Libecap, 2014; Ostrom, 2003; Rayamajhee et al., 2021, also see Barzel, 1985). Furthermore, two or more resource systems with similar underlying biophysical characteristics can have varying degrees of divisibility and assignability due to differences in these interacting factors.

For example, high seas fisheries that are beyond national jurisdiction pose significantly more difficult conservation challenges compared to small-scale in-land fisheries (Paniagua & Rayamajhee, 2023). Property-rights-based solutions that assume divisibility and assignability of the resource system may be unavailable in the high seas fisheries, due to political, geographical, and technological factors. However, the severity of the challenges can be mitigated with the adoption of new and/or improved technology (such as Artificial Intelligence) and utilizing new sources of data (such as high-resolution and high-frequency satellite imaging). Such innovations can reduce the costs of defining and identifying property rights, effectively moving an externality problem down the vertical axis to become more

solvable in ways previously not possible. In other instances, technological changes can exacerbate excludability challenges–for example, by providing new opportunities and tools for free riders.

Before proceeding further, it is worth noting that the motivation behind the proposed taxonomy is to help scholars map different types of externalities on to suitable governance institutions in the real world by accounting for their intrinsic scalar feature and their institutional attribute. The goal is not to map out every existing type of externality, nor is it to generalize that a specific example of externality belongs to a certain quadrant. In classifying specific examples, we have made certain institutional assumptions with the hope that they may serve a useful illustrative purpose. That said, we caution readers not to interpret the classification as an attempt to cement a specific example of externality to a specific type or box.

4.1 Different types of externalities and their properties

Cases I–III in Fig. 1 are recognized as being relatively easy[2] to solve, thanks to a voluminous body of work extending Coase's pathbreaking analyses of transaction costs (for example, see Cheung, 1973; Demsetz, 1970). Type I represents a scenario in which the scale is small and the tasks of assigning and enforcing property rights are easy. Take the hypothetical example introduced by Coase (1960) involving a cattle raiser and a farmer. The cattle raiser owns straying cattle that destroy a farmer's crops on neighboring land. When transaction costs are tolerable, the cattle raiser and the farmer can come to a mutually desirable arrangement to resolve the externality regardless of the initial assignment of property rights. It does not matter with regard to allocative efficiency whether the cattle raiser is liable for the damages (Coase, 1960).

Coase argued that if the farmer possesses property rights that protect her crops from the cattle, the cattle raiser is obligated to compensate her; and, if the cattle raiser is rational, he will compensate her, up to the point at which the marginal benefit from having additional cattle graze on the nearby farm exceeds the compensation value. If the cattle raiser is not obligated to pay, it is in the farmer's best interest to pay the cattle raiser not to let his animals stray onto her farmland; and a rational farmer will do so, as long as the marginal benefit of the crops exceeds the value of the payment. Thus, both parties have incentives to come to a mutually beneficial market-based agreement that minimizes harm (or maximizes revenue). Other common examples of easy cases of small-scale externalities include the case in which a tenant's negligence leads to damages to the landlord and the case in which a beekeeper benefits from the neighboring apple orchard but does not provide compensation (Boudreaux & Meiners, 2019; Muth et al., 2003).

Type II depicts scenarios in which the scale of the externality is greater (and the number of affecting or affected parties is higher) and thus requires multilateral negotiations. If property rights are assignable and enforceable at low costs, externalities can be internalized. An example of a situation involving a medium-scale externality in a case in which property rights can be easily assigned and enforced is when the operation of a hydropower dam upstream destroys crops owned by farmers in downstream villages. Although the scale of this externality is larger than that of type I—it involves multiple farmers and the firm's

[2] These types of externalities are easy to solve in the sense that one can govern them without diverting significant public resources through collective schemes.

stakeholders—an arrangement that satisfies both the firm's stakeholders and the downstream farmers is feasible without intervention by external regulatory authorities. This is because property rights for both the crops destroyed and the hydroelectricity generated can be easily assigned and implemented; moreover, market prices for both goods are readily available, and negotiations between farmers' representatives and the firm's management are possible (Rayamajhee & Joshi, 2018). Even when multiple firms are involved and the number of affected farmers increases, endogenous solutions through multilateral bargaining remain feasible, provided the institutional environment facilitates conflict resolution.

Type III represents a scenario in which large scale presents coordination challenges. When the scale of an externality exceeds a certain threshold, Coasean bargaining becomes too cumbersome irrespective of the relative ease of assigning and enforcing property rights. Nonetheless, the need for endless bargaining can be avoided by innovating new institutional and technological mechanisms for assigning and enforcing tradable property rights. The greater scale of the problem and the relative ease with which property rights can be established and enforced create numerous possibilities for governance solutions. How the precise solutions end up materializing will depend on the institutional environment and the interplay of private and public incentives (Ostrom, 2005).

Where commerce is permitted and encouraged, private entrepreneurs may find new avenues for profit by introducing tools and private clubs to mitigate externalities. The case of online piracy affecting content creators and publishers worldwide is an example of a large-scale externality that are easily solvable by private entrepreneurs because property rights over the associated technological services (for example, music, e-books, and other digital products) are easy to assign and implement. The emergence and proliferation of services such as Spotify, HBO Max, Netflix, Scribd provide examples of entrepreneurial solutions that are possible due to large economies of scale and the relative ease with which property rights can be established, enforced, and traded. While online piracy is still feasible and prevalent, technological entrepreneurs have successfully devised ways to provide digital content at sufficiently low marginal costs to attract paying subscribers and induce content providers to keep up production despite freeriding possibilities.

In situations where the relevant markets are not permitted or cannot satisfactorily solve the problem, public and social entrepreneurs or organizations may devise more complex institutional solutions to circumvent the problem. For example, consider the creation of national parks for the purpose of biodiversity protection. As Libecap (2014) notes, "The scientific benefits of reserving particular sites are typically well known because of extensive studies and observation by researchers and wildlife advocates" (ibid., p. 438). Property rights are relatively easy to establish and implement because of low scientific uncertainty, low information asymmetry, low enforcement costs, and relatively homogeneous perceptions and preferences (ibid.). Thus, in the absence of private markets, public (and social) enterprises and organizations may be able to effectively internalize the externality. The larger scale, coupled with low costs of property rights assignment, enforcement, and exchange, means that large economies of scale exist, and that the possibility of Pareto improvement is immense. Thus, this type of externality (type III) is unlikely to remain unaddressed for too long in societies with minimally good governance and vibrant markets (Ostrom, 1990).

Cases IV–VI in Fig. 1 represent more difficult situations in which establishing and enforcing property rights require substantial institutional ingenuity but are nonetheless

possible.[3] A good example of type IV is a small-scale externality problem facing the six hundred CPR users of communally owned land in Törbel, Switzerland (Ostrom, 1990, p. 61). The communal nature of resource systems such as grazing grounds presents numerous externality challenges; in general, resource users face incentives to over-extract resources and contribute little to their maintenance. However, for centuries (dating back to 1224), residents of Törbel have successfully managed different types of communally owned property, minimizing externality problems arising from their communal character. For instance, to avoid overexploitation of the grazing grounds, they devised detailed written codes dating back to 1517, that assign various (non-tradable) rights and responsibilities to users and managers of the resource system. To minimize externality challenges pertaining to overgrazing, they designed rules stipulating appropriation rights (referred to as "cow rights") that specify how many cows each villager can send and for how long; the rules also affect the amount of cheese each household is eligible for during the annual distribution (ibid.). The rules are enforceable at low cost, despite the absence of formal markets, because the villagers have pre-existing social relations and a shared history that leads to high social trust. Moreover, the *de jure* codes governing resource appropriation and maintenance are well respected because they include mechanisms to address grievances or adapt the rules when equity and other concerns arise in response to changing economic and environmental factors.

Type V is similar to type IV in that participants face significant but addressable difficulties in establishing and enforcing property rights. But the scale of externalities is larger; thus, more parties are involved, and externalities often span multiple jurisdictions. Well-documented cases of offshore and large fisheries in the United States provide good examples of medium- to large-scale externality problems with significant difficulties of establishing and enforcing property rights (Libecap, 1994, 2014; Paniagua & Rayamajhee, 2023). Geography and nature impose many of these difficulties: "The areas involved are extensive and government jurisdictions overlap" (Libecap, 1994, p. 576). In most cases, there are no restrictions on entry and harvest, in part due to the fluid and migratory nature of many species, but also due to legal prohibition of private or communal property rights. As a result, each fisher, in trying to maximize private benefits, imposes external costs on other fishers by scattering fish and depleting the stock (ibid., p. 577). This problem can lead to complex externality challenges such as fish-habitat degradation, poor economic returns, and social hardships (Grafton et al., 2008). Although successful governance is possible, it requires overcoming substantial information and coordination failures and establishing appropriate institutions (or modify existing institutions) to address highly context-specific challenges in different areas.

Libecap's (2009) portrayal of water governance challenges in Owens Valley, California presents another depiction of a medium-to-large-scale externality situation that is difficult to resolve by assigning and implementing property rights. The Los Angeles Board of Water (the Board), in attempt to transfer water from Owens valley to the city, tried purchasing all the farmland in the valley. The fugitive nature of the resource (water) meant that certain property rights (for example, ownership) are difficult to define and implement. Moreover, because the resource is shared by thousands of users, internalization of an externality stemming from one user's decisions and actions would require overcoming major coordination challenges. From the Board's perspective, the water transfer would be meaningful only if it could purchase all the farmland because the value of the aqueduct that it managed depended

[3] Trading of certain rights (for example, ownership) is nonetheless highly restricted.

on the flow of water from the valley. For an individual farmer, gains from sale (or holdout) depended on her relative bargaining strengths and on the decisions of other farmers. Large-scale farmers who could organize and hold out for longer would have better bargaining positions than farmers with a smaller size farmland. Those who were uninformed and unable to organize—that is, over 7000 Owen Valley farmers who typically owned small to medium size farmland of varying productive potential and value—benefitted proportionally less or incurred losses from the transfer. They received the brunt of the externality that occurred due to "voluntary" exchanges between willing sellers (better informed and well-organized owners of larger farmland) and the Board. The transfer was controversial, intense, and even violent at times, and has been dubbed as "the most notorious water grab" in history (ibid., p. 311).

Type VI involves externalities similar in nature to that of types IV and V, albeit at a much larger scale, often extending to many countries or even continents. For example, consider the proposed China–Nepal railway project, a flagship infrastructural project that is part of the Trans-Himalayan Multi-dimensional Connectivity Network funded by the Chinese Belt and Road Initiative. The railway system, once in operation, will likely generate many economic opportunities and positive externalities. However, it will almost certainly result in numerous environmental externalities as well, such as wildlife mortality, barrier effects, biological invasions, and noise and chemical pollution (Lucas et al., 2017). These environmental externalities will be difficult to address because of their transnational nature and because of unequal power relations between the two nations. For instance, if operations of a Chinese railway company in the Himalayan belt of Nepal destroy rare species of plants and deteriorate the overall quality of communally managed forests, this externality will likely not be internalized in a manner that the affected communities will find agreeable. Solving such large-scale problems spanning multiple governmental jurisdictions at different scales will require high-level political or bureaucratic negotiations, which are difficult and costly to organize and tend to focus on geopolitical and macroeconomic issues. Moreover, users of community forests face significant difficulties in convincing national-level bureaucratic and political actors to negotiate on their behalf.

Types VII, VIII, and IX in Fig. 1 represent situations in which the task of internalizing externalities is extremely difficult or infeasible, either because the costs of internalization are high relative to the individual benefits or because of limits to scientific knowledge and mitigation technology. For instance, small-scale externalities that are extremely difficult or costly to resolve through property rights assignment and enforcement (type VII) are usually not worth addressing, hence they are *inframarginal* (Buchanan & Stubblebine, 1962). These include externalities for which the costs of internalization far exceed the personal benefits, or what Buchanan referred to as Pareto-irrelevant externalities (Buchanan, 1973; Buchanan & Stubblebine, 1962). For example, the costs of creating rules, organizing collective action, and establishing a special police force to prevent smelly subway passengers from affecting their fellow passengers far exceeds the potential benefits from keeping smelly passengers off the subway. Buchanan and Tullock's (1962, ch. 5) famous red-underwear example presumably also fits this case, as the solutions are not worth the potentially high decision-making, negotiation, and enforcement costs.[4] As they note, "Even when it is possible to remove all

[4] Buchanan and Tullock (1962) present this as a case of zero decision costs but nonzero private costs. For individuals who find red underwear nauseating and hold strong judgments about other people's undergarments, this may become a negative externality.

external effects that are involved in the organization of an activity, it will rarely, if ever, be rational for the individual to seek this state of affairs because of the decision-making costs that will be introduced" (ibid., p. 44).

Types VIII and IX represent situations characterized by medium-to-large-scale externalities that are extremely difficult to resolve by assigning and enforcing property rights. Unlike type VII, where the small size provides plausible justification for inaction, externalities represented by types VIII and IX are sufficiently large, and potentially dangerous to human welfare, that they will not or cannot be ignored, irrespective of the magnitude of mitigation costs that may be incurred. Even when effective solutions seem to be absent and existing solutions do not pass the benefit-cost test, such externalities tend to garner considerable public attention and concern and engender significant public investment in mitigation efforts (Paniagua, 2022). Some of these externalities may be individually interpreted as Pareto irrelevant, in Buchanan and Stubblebine's (1962) terms, because the affected party (or parties) cannot be made better off without making the unaffected parties worse off. However, they are also Pareto defying in the sense that public sentiments and political incentives associated with medium-to-large-scale externalities tend to result in an outpouring of public attention, social concern, and investment in mitigation (Ostrom, 2012).

A fitting illustration of a type-VIII externality is the light pollution resulting from installing streetlights in cities. Cities install streetlights because they help improve nighttime visibility, reduce crime, and (arguably) increase transportation safety (Doleac & Sanders, 2015; Gerdes, 2013). However, streetlight-induced light pollution can have many potential direct and indirect adverse health consequences, including increase probabilities of insomnia, obesity, and conceivably even cancer, thus producing medium-to-large-scale negative externalities (Haim & Portnov, 2013). For instance, Jones (2018) finds that Los Angeles's 2009 LED streetlight efficiency program, which installed 141,089 LED streetlights in the city, led to a non-negligible increase in breast cancer mortality of 0.479 per 100,000 people. Epidemiological literature also documents that artificial lights at night disrupt the circadian rhythm, thus leading to decreases in melatonin and increasing the risk of breast cancer (Stevens, 2011). Although private citizens can adopt various measures to protect themselves from the adverse effects, such measures only work to an extent because limiting regular exposure to streetlights is difficult (Haim & Portnov, 2013). City governments could adopt other alternatives—for example, by replacing LED lights with gas lamps—but that would lead to other externalities such as increased fire risk and methane emissions. While marginal improvements may be possible through technological innovation, permanent collective solutions remain extremely costly or infeasible. Thus, city officials and citizens (taxpayers) are likely left to weigh the costs and benefits of different kinds of streetlight technologies and thus pick their externality of choice based on the trade-offs involved. Municipality and/or city-level policing services and associated externalities (for example, police brutality) provide other contemporary examples of medium scale externalities that are not feasible to solve by assigning and enforcing (marketable) property rights. For many externalities of this type, citizen co-production and the use of available technology play important roles in minimizing pernicious impacts and improving cost-effectiveness of existing policies and solutions (Ferrazares, 2023; Ostrom et al., 1977; Rayamajhee et al., 2021).

Finally, type IX represents externalities that are too large to fall under the purview of a single overarching governing institution and for which it is too difficult to assign and enforce tradable property rights to internalize them. Global climate change and pandemics

are obvious examples. Externalities of this type tend to be nested in nature; that is, "actions taken within one decision-making unit simultaneously generate costs or benefits for other units organized at different scales" (Ostrom, 2012, p. 356). The temptation to treat such externalities as homogeneous problems to be solved by a national or global authority is ever present. However, as the recent pandemic has shown, collective action challenges associated with pandemics vary widely across national and subnational jurisdictions, cultures, and even communities (Paniagua & Rayamajhee, 2021). Thus, concerted efforts by governments and governance organizations at all levels, as well as private and nongovernmental actors are required to have any hope of finding a sustainable solution (Paniagua, 2022). Moreover, measures taken to mitigate nested externalities are *co-productive* in nature: they require active inputs and direct engagement from all participants at different scales (Paniagua & Rayamajhee, 2021; Rayamajhee & Paniagua, 2022; Rayamajhee et al., 2021).

5 Conclusion

This paper shows that many new valuable insights on externalities can be generated by incorporating James Buchanan's and Elinor Ostrom's analyses of collective action, property rights, and institutions into the transaction costs theory advanced by Ronald Coase. The scope of this article has been to highlight the interplay between the scalar attribute of a given externality and the ease with which property rights can be assigned, enforced, and exchanged to internalize it. This provides a novel classification of externalities along these two often conflated dimensions, showing that focusing on their interaction provides a fruitful path forward to conceptualize and taxonomize externalities in a manner consistent with the institutional diversity that characterizes our polycentric society. The proposed approach adds enough nuance to account for both the intrinsic characteristics of a given externality (their nature) and the institutional context within which it is embedded (the institutional structure). Thus, this approach makes it possible to map externalities to the most appropriate class of institutions to address them, and it evades the unproductive market-versus-state dichotomy (Furton & Martin, 2019; Ostrom, 2010; Rayamajhee and Paniagua, 2021).

Neither the mere presence of externalities nor their magnitude alone justifies external intervention or governmental action to internalize them and restore equilibrium. This paper indicates that the two attributes of externalities *jointly determine* the costs and benefits of different institutional solutions and their economic viability. For each of the nine types of externalities discussed and presented in the taxonomy, the degrees of costs and benefits vary based on which set of institutions arises to reconcile them. In an institutional environment that encourages market solutions, various market-based organizations can emerge to tackle small-to-large-scale externalities. But where property rights are absent or difficult to establish because of technical barriers, private firms and communities can innovate by producing club-like arrangements, exclusion mechanisms, and technologies to internalize externalities to a tolerable level. In settings in which transactions are infeasible or forbidden—for reasons such as the absence of markets, legal barriers, institutional norms prohibiting transactional relations, or lack of technology—communities can generate governance structures and rules, at different levels, to repackage property rights and participate in non-market collaborative processes to minimize externalities. Finally, complex, large-scale externality problems such as climate change and pandemics tend to be nested in nature, and such prob-

lems require nested or multiscale solutions, where individual citizens, communities, private firms, non-governmental organizations, and governments at various levels all have vital roles to play (Ostrom, 2012; Paniagua, 2022; Paniagua & Rayamajhee, 2021).

Externalities are ubiquitous, and our utility functions are interdependent. In fact, the inevitable interdependency of production functions is what makes social progress and civilization possible. Without intertemporal and interspatial interdependencies between consumers and producers, none of today's problems and achievements would exist; our material and social progress as well as our pressing challenges are due to the ubiquitous divergence between private and social costs and benefits. Hence, simply noting that private costs and benefits do not equal social costs and benefits in any given exchange situation tells us very little about whether the divergence needs to be rectified; nor does it reveal to us what type of institution is most suited to address it, if any at all. Hence, any serious analysis must account for both the intrinsic features of the externality and the details of the institutional setting within which the externality manifests. This paper has contributed to putting all these crucial concerns at the forefront of the analysis of externalities, thus delineating a path forward for future public choice scholarship.

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