

Externalities and Institutional Diversity

Pablo Paniagua[†] & Veeshan Rayamajhee^ψ

ROUGH DRAFT

Please do not distribute or cite.

(August 16, 2022)

[†] Pablo Paniagua, Centre for the Study of Governance and Society, King's College London. Corresponding author: pablo.paniagua_prieto@kcl.ac.uk

^ψ Veeshan Rayamajhee, Department of Agribusiness and Applied Economics, North Dakota State University.

Abstract

This article contributes to the literature on externalities and their classification by reconciling insights from the transaction costs theory with Elinor Ostrom's analyses of property rights and institutional diversity. We critique the dominant Pigouvian framework that assumes only two forms of institutions to overcome internalize externalities, namely, governments or private markets, and develop a new framework for taxonomizing externalities that provides space for a wide array of institutions that the market-vs-state dichotomy ignores. The proposed taxonomy considers two classes of often conflated attributes: 1) the scale of externalities, and 2) the assignability and enforceability of property rights. We show that the Ostromian approach enriches the Coasean transaction costs perspective by stimulating unbundling of transaction costs and thus extends its usefulness to strictly non-market situations where transactions are either not permitted or technically infeasible. Thus, the integration of insights from two distinct institutional approaches can broaden the theory of transaction costs that encompasses market exchanges but goes well beyond them by incorporating cases where property rights are, and will remain, unclear. We conclude that institutional diversity based on experimentation and contestation can offer innovative, pragmatic, and adaptable solutions to tackle small- and large- scale externalities.

Keywords: Transaction Costs, Property Rights, Externalities; Institutions; Elinor Ostrom

JEL classifications: E02, E58, H41, P5, P16, P26

1. Introduction

The presence and severity of externalities are chief economic justifications presented in support of collectivizing an activity. Externalities provide an individual with an economic basis for contemplating whether or not to enter into a “political relationship with his [one’s] fellows” (Buchanan & Tullock, 1962; also see Keech & Munger, 2015). When private exchanges generate unpriced costs and benefits to third parties not involved in the exchange process, the standard competitive equilibrium logic dictates that an external authority ought to regulate or intervene, typically through some forms of corrective taxes (in the case of negative externalities) or corrective subsidies (in the case of positive externalities) to ‘internalize’ it (Hyman, 2014, p. 93-99). The effectiveness of the external authority to accomplish the tasks of internalization rests on its ability to accurately measure the said externality, identify the affected individuals, and implement the corrective measures. However, public choice scholars have long noted that governments fall far short of meeting those standards (Buchanan & Stubblebine, 1962; Leeson & Thompson, 2021; Tullock, 1998). Moreover, they have also shown that government decisions taken to ‘correct’ one externality situation can produce many other unanticipated externalities (Tullock, 1998, p. 414).

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 to warrant governmental intervention. If the estimated total benefits of collectivizing an activity exceeds the expected total costs of doing so – on account of economies of scale and uncertainties – that offers a sufficient basis for collective action (Buchanan & Tullock, 1962; E. Ostrom, 1968). But this does not mean *governments* should intervene. Buchanan and Tullock (1962) noted that what institutions (markets, governments, or voluntary organizations) should rational individuals choose to collectivize the activity depends on the relative *costs of social interdependence* – which is the sum of external costs and decision-making costs (p. 44, 46). This logic would lead us to conclude that we need to compare a whole gamut of existing institutional arrangements – not just markets and governments – to make an analytically sound determination regarding the appropriate institution suited to minimize interdependent costs. This conclusion seems straightforward. However, economists, including scholars of the public choice tradition, have remained stubbornly immersed in the market-versus-state tug-of-war. This has led to contentious, and often ideology-laden debates

about the relative pitfalls of markets or states, with one camp focusing on ‘market failure’ (and hence the need for governmental intervention) and the other camp fixating on ‘government failure’ (hence appeals for freer markets) (Furton & Martin, 2019). What is worse – for far too long, this has permitted fellow economists to conveniently ignore a vast array of institutional configurations that individuals across communities and cultures have devised to internalize many externalities (Furton & Martin, 2019; E. Ostrom, 2010; Rayamajhee & Paniagua, 2021).

Modern economists such as James Buchanan, Gordon Tullock, Ronald Coase, and Elinor Ostrom have advocated for comparative analyses of alternative institutions engaged in the business of internalizing externalities. Yet, much of the contemporary scholarship, particularly within the field of economics, remains largely fixated in the markets-versus-states dichotomy, focusing either on different forms of governmental interventions to mitigate externalities or on the creation of de jure property rights and judicial reforms to decrease transaction costs (Medema, 2020b). Coase (1992) attributes this to economists’ preoccupation with abstraction of analyses, which has resulted in a “neglect of the market or more specifically the institutional arrangements which govern the process of exchange” (p. 714). He urged economists to shift their focus away from the fictitious institution-free systems which exists only “in the minds of economists but not on earth” and instead devote their attention to non-ideal economies rife with (often high) institutional opportunity costs (p. 714). Ostrom (1986) suggests that this is in part due to the lack of effective communication between institutions scholars from different academic disciplines and the absence of integration of multidisciplinary insights (p. 4). Whatever the causes may be, it remains true today that economists continue to think in binary terms – presuming only two forms of institutional organizations to address externalities exist, namely markets and states – and disregard diverse forms of governance structures that lie in between (E. Ostrom, 2010; Rayamajhee & Paniagua, 2021). This disregard has led to a blurring of a large swatch of neither-market-nor-state institutions governing modern societies: various forms of cooperatives, local institutions, self-organized common pool resource institutions, local public economies, and civil societies, which actively internalize many externalities, are either ignored or erroneously classified as markets or states.

This article maps a way out of the market-state dichotomy trap by synthesizing insights from the transaction costs theory (TCT) with the Bloomington school’s analyses of institutional diversity

and property rights. We reconcile ideas from the two intellectual giants, Ronald Coase and Elinor Ostrom, in the form of a revised taxonomy of externalities which unbundles transaction costs and extends the theory's usefulness to strictly non-market situations where transactions are either not permitted or technically infeasible. The proposed taxonomy decouples the scalar (size/scale) and institutional (property rights) components of transaction costs and brings together insights from the two traditions (Ostromian and Coasean) both of which have advanced comparative institutional analysis as a more useful methodological alternative to the Pigouvian framework for analyzing externalities.

The remainder of this essay is structured as follows. We begin the next section by reviewing various ways economists have conceptualized and taxonomized externalities. We discuss the shift from abstract, high-level theorizing of externalities to an empirical, institutional emphasis during the 1960s following the contributions of Ronald Coase and others. We point out that although Coase's works had lasting influence on economic thought, his broader methodological call for adopting comparative institutional analysis was largely neglected. Next, we reconcile Coase's and Ostrom's approaches to externalities and distinguish it from the rest. We argue that Ostrom's contributions to the analysis of non-tradeable property rights in common pool resource (CPR) systems can expand the scope of the transaction costs theory to non-transactable situations and extend its usefulness beyond the confines of law and economics. We then discuss the importance that James Buchanan and Elinor Ostrom placed on the scale/size factor of externalities in determining their relevance. The subsequent section proposes a new taxonomy of externalities that is compatible with conducting comparative institutional analysis. Using various empirical illustrations from the existing literature, we show that the interplay between the scalar (size/scale) and institutional (assignability of enforceability of property rights) jointly determine the economic viability and cost-effectiveness of different institutional solutions. Finally, we conclude by discussing implications of the new taxonomy.

2. Conventional classifications of externalities

Modern economists have been preoccupied with categorizing externalities owing to diverse motivations.¹ Some examples of influential classifications include ones proposed by Meade (1952),

¹ See Medema (2020) for an excellent summary of various treatments of externalities by economists.

Scitovsky (1954), Bator (1957, 1958), Buchanan and Stubblebine (1962), and recent one by Leeson and Rouanet (2021).² Meade's (1952) classification was part of his larger project to bring in theoretical tools from welfare economics to shed some light into issues of trade and development (Medema, 2020a). He categorized externalities into two types – the “unpaid factors of production” and “atmospheric” externalities. The first case is typified by the apple farmer and beekeeper conundrum, where the beekeeper benefits from apple farmer's contribution to the production of honey but does not pay for the inputs. The second case occurs when the activities of one producer creates an “atmosphere” favorable (or unfavorable) to the activities of other producers. He concluded that the latter case is more challenging, because of various issues: differences in marginal valuation of the “atmosphere” by benefiting producers, measurement issues, and coordination problems that preclude negotiations between the concerned parties.

Scitovsky's (1954) classification of externalities was based on what he called “direct interdependence” between agents in an economy that led to sub-optimality – relative to the Pareto optimality case of competitive equilibrium. He classified externalities into four types: 1) situations where one consumer's utility depends on other consumers' utilities (“Veblen effects”), 2) situations where a producer's actions affect consumer utilities in ways unaccounted by prices (e.g., factory pollution affecting communities), 3) situations where a producer's output is affected by other producers and consumers who are not in a direct economic relationship with it (e.g., a new openly available battery technology that improves computers), and 4) situations where one producer's output is affected by the production activities of other firms (e.g., beekeeper freely benefiting from apple farmer's inputs). Scitovsky's classification was an attempt to illuminate ways in which costs and benefits unaccounted by the price system enter the production and utility functions, thereby affecting competitive equilibrium.

Bator (1957, 1958), in an attempt to clarify *why* unpriced exchanges occur, classified externalities into different types. Bator's classification situates the notion of externality within the broader theory of competitive equilibrium. It is noteworthy that his's classification is not of externalities per se,

² Leeson and Rouanet's (2021) do not provide a general classification of externalities; their classification is in the specific context of the COVID-19 pandemic.

but of the ways in which market fails because of their presence.³ For Bator, market fails because of the presence of three classes of externalities: 1) ownership externalities (essentially Meade’s “unpaid factors of production”), which exist because of “more or less arbitrary or accidental circumstances of institutions, laws, customs, or feasibility” and that prevent appropriate pricing of inputs and outputs (Bator, 1958: 364); 2) technical externalities, which are a result of “indivisibility or smooth increasing returns to scale in the relevant range of output” such that some social costs and benefits are not internalized in a firm’s decentralized profitability calculations (p. 366), and; 3) public good externalities⁴, which occurs when goods or services are of “joint consumption nature” – that is, the good or service enters jointly into the utility functions of multiple consumers (p. 369). Externalities, in Bator’s classification system, are relevant to economists because they lead to “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” (Bator, 1958: 351). Neither the empirical relevance of externalities and their ubiquity in all market and non-market exchanges, nor their intrinsic characteristics, are the primary motivations or the starting point of analysis for Bator’s theorizing and classification.

The rise of environmental economics, health economics, law and economics, and other applied subfields in economics during the 1960s brought economics down from the abstract, high-level theory to specific real world problems (Medema, 2020a; Papandreou, 1998). This shift toward analyzing real world phenomena 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 Ronald Coase (1992, 1959, 1960, 1974) – which covered detailed analyses of externalities ranging from the railway fires and lighthouses in the Great Britain to the broadcasting stations in the United States. In Coase (1974), he notes that, although prior studies have extensively used the lighthouse example, none have taken a detailed look at the financial and administrative aspects of lighthouse operation. They are simply “plucked out of the air to serve as an illustration” to provide corroborative detail to a presumed foregone conclusion derived from abstract theorizing (p. 375).

³ Hence the title “The Anatomy of Market Failure.”

⁴ This is the well-known Samuelsonian public goods case (Samuelson, 1954; also see Rayamajhee & Paniagua, 2021).

Although much of the scholarly attention is devoted to the Coase theorem – which shows that parties can come to an efficient resolution of externality problems if price system is costless and property rights are assigned – Ronald Coase emphasized even more forcefully on the analytical method he chose to derive the theorem, namely comparative institutional analysis (Medema, 2020b). From the Coasean economic point of view, the goal then is not to seek the elusive optimality of the zero transaction costs world but to choose from among imperfect alternatives the mechanism that “maximizes the value of output for the problem under consideration” (ibid., 1051). Unfortunately, but expectedly, the broader discipline ignored his calls to move away from what he called “blackboard economics” of the presumed zero transaction costs world and to adopt comparative institutional analysis (CIA) to study real-world externalities problems. CIA, the way Coase sees it, stipulates that all institutional solutions – including both market and state solutions – are rife with transaction costs and the preferred solution aims to minimize net costs, which includes transaction costs.

Had the broader discipline taken up Coase’s methodological call for adopting comparative institutional analysis, we could have possibly avoided reclassifying externalities once again, – this time along the lines of market versus state solutions— and moved towards paying closer attention to the interaction between the intrinsic attributes of specific externalities and the institutional environment. However, that did not happen. Economists continued to interpret Coase’s central contribution singularly as a rebuttal of the Pigouvian presumption that the responsibility of internalizing externality rests on the state. Post Coase (1960), economists were either ‘Pigouvians,’ who favored state solutions to externality problems, or ‘Coaseans,’ who favored market exchanges facilitated by well-assigned property rights. Harold Demsetz (1996), for instance, argues that Coase’s main methodological contribution was his privatization of the externality problem, not his insights on transaction costs or comparative institutional analysis” (p. 566). As he further notes, “the core disagreement was in Pigou’s willingness to rely on an omniscient State to implement policy and Coase’s refusal to do so” (p. 565).

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 of externalities to examining real-world problems. However, it also made the intellectual discourse unnecessarily contentious and ideology laden – thus rupturing the suture between the laissez fair 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 – disregarding the fact that the zero-transaction cost model is the neoclassical paradigm and not Coase’s assertion; Coase’s world is one of positive transaction costs. They argued, rightfully, that the zero-transaction cost model reduced the function of the state to assigning and enforcing private property rights and allowing market exchanges and private negotiations to resolve externality problems. Others took Coase’s positive transaction cost model more seriously but pointed out that it is insufficient to refute state involvement in solving externality problems and even provides a basis for state involvement in situations where high transaction costs preclude private exchanges.

3. Coase’s and Ostrom’s treatment of externalities

Where Ronald Coase’s (1959, 1960, 1974) and Elinor Ostrom’s (1992, 2002, 2003) approaches to externalities differ from the rest 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; they did not stem from their desires to fill logical gaps in the neoclassical market 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 correspondences, policy proposals and bills, legal proceedings, and contextual facts, and employed transaction cost approach to improve understanding. Ostrom used mixed methods approach, employing both qualitative and quantitative tools and grounded her findings using game theory and analytical narrative.

Before emigrating to the United States, Coase’s primary research focus was on the case studies of regulated industries, including the broadcasting sector, in Great Britain (Medema, 2020b). After he moved to the States, he continued his investigations of the broadcasting sector and started focusing on the political economy of the Federal Communications Commission and its methods of allocating broadcast frequencies. These efforts culminated to his influential work titled *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 FCC full control over radio communication – can generate misaligned incentives resulting in the tragedy of the commons where they need not exist. Similarly, in a different article, Coase (1974b) conducted a detailed analysis of several privately provided lighthouses in England from 1610 to 1675 that operated with no 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 of these 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. That is, actual market solutions should be compared against actual governmental solutions, not fictional ones. He argues that we ought to “start out 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: 876). Reality, not a hypothetical benchmark based on blackboard theory, should form the basis of comparing the performance of alternative institutions. One can go so far as to claim that the apparent superiority of private solutions over governmental ones in these cases are mere distractions.

Like Coase, Ostrom 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 many resource user communities, where local institutional norms either did not permit or outright forbade explicit transactions. Nor are these terms fully illustrative of non-market decision-making processes at collective-choice or constitutional levels where participants form and alter operational rules to solve social dilemmas that have a strong non-transactional emphasis. Although the focus of Ostrom's study was on common pool resource (CPR) systems, she covered a broad range of collective action problems

across all levels (across operational, collective-choice, and constitutional) – including cases where transactions were permissible and feasible, and cases where they were not. She had a highly interdisciplinary research agenda; her strategy was to draw on the foundations of multiple disciplines – economics, political science, psychology, sociology, anthropology, biology, and law, among others – using a common framework applicable to all disciplines. Thus, Ostrom and 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 in transaction cost terms.

3.1 Non-tradable rights and Ostrom

Thus far, scholarly focus has been placed overwhelmingly on the creation of formal legal and tradable private rights as an alternative to top-down regulatory approaches to externality mitigation. Simply put, the solution has been to convert non-tradeable situations into tradeable ones. Where that is not feasible, owing to insurmountable transaction costs, state involvement is called for. The underlying assumption that motivates this dichotomous thinking is that only two forms of organizations – markets and states – are relevant for resource allocation (Furton & Martin, 2019; E. Ostrom, 2010; Rayamajhee & Paniagua, 2021). We argue that the transaction cost perspective can benefit from recognizing the presence of non-tradable property rights – rights that, despite being non-tradable, grant the right-holders certain authority to control the specific good or resource system with varying degrees and benefit from them. Further recognition of what Hodgson (2015) calls ‘legal impermeability’ – situations where it is “too costly [or perhaps even impossible] to use the law” because the legal transaction costs are insurmountable – is needed if we are to advance beyond the market-versus-state roadblock.

An argument we forward in this essay is that Ostrom extended insights from transaction costs theory to study self-governance in circumstances where transactions, at least in their strictest sense of exchanging ownership rights, are infeasible or impermissible – either because markets are absent or the legal route of assigning and enforcing property rights is unavailable. According to Ostrom, although legal and governmental authorities play important roles – by granting minimal recognition

to de facto institutions and, when necessary, by providing avenues for conflict resolution⁵ – the legal or governmental route is often insufficient to avoid problems posed by non-tradability.

Ostrom distinguished between formal rules (*de jure rules*) and rules in use (*de facto rules*). She demonstrated that in many contexts, de jure rules are not compatible with the geophysical conditions, institutional environment, features of the resource systems, and the attributes of the communities. To circumvent the incompatibility issue, resource users frequently devise norms and rules (de facto rules) that are better suited to solve their externality problems.

Ostrom's analysis went well beyond the confines of law and economics, acknowledging that there are innumerable cases where externality problems cannot be solved by creating and enforcing property rights. This does not mean that property rights are irrelevant – far from it. Often, when easily tradable property rights are not available, individuals create more complex institutional and governance structures to create more intricate 'bundles of rights' associated with different social positions within local collective action arrangements (Ostrom, 1990, 2003; Schlager & Ostrom, 1992). Ostrom's point was that we need a more nuanced view of property rights and externalities that may not be immediately apparent when viewed solely from the law and economics perspective.

In their analysis of a fishery systems in Maine, Schlager & Ostrom (1992) outline five non-tradeable de facto property rights that are not statutes handed down by any regulatory agency but developed and implemented by resource users themselves to solve externality problems: namely, access rights, withdrawal rights, management rights, exclusion rights, and alienation rights. Groups of individuals, facing an externality or a social dilemma, bypassed both non-tradability and non-divisibility issues by assigning separate positions and roles (rights and responsibilities) to different individuals, and creating rules 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 (e.g., fishing time and size of nets one can use to extract fish), but lacks the right to alienate the resource system. On the other hand, individuals designated as resource users may only have the operational level right to withdraw from a resource system as determined by operational rules. Even though no explicit forms of transactions in an economic or legal sense take place in these instances, successful minimization of monitoring costs,

⁵ Design principles 6 and 7 (see Ostrom, 1990: p. 90).

sanctioning costs, and decision costs does occur – through self-devised mechanisms beyond the purview of markets or states.

It is worth pointing out that the ‘bundle of rights’ that fishers in Maine developed, as documented in the referenced study, may or may not be readily applicable to other resource systems. One cannot determine ex ante what specific bundles of rights may have been developed and implemented in a specific instance and what institutional configurations exist on the ground. Complex non-tradeable ‘bundle of rights’ that may not be captured by the above five categories of rights can emerge to address context specific problems. Thus, an analyst using high-level theories of competitive equilibrium, trade, or economic growth to understand externality will inevitably lack the necessary institutional knowledge to carry out this exercise in a policy relevant manner.

3.2 Size/scale factors of externalities according to Ostrom and Buchanan

The scale or size of the externality should be an obvious starting point in determining its policy relevance or classifying it. The nuisance caused by one’s loud neighbor is a much smaller externality relative to the spreading of coronavirus or the manufacturing sector’s effects on air quality. Yet this consideration was not accounted for in Meade’s, Scitovsky’s, Bator’s classifications. Their attention was devoted to ways in which an abstract externality entered the utility and production functions, and how it affected the competitive market equilibrium.

Buchanan (1973) recognized the scale consideration indirectly, noting that when many parties are involved (correlated with the size of the externality), the number of interactions required to negotiate property rights exchange rises and prevents “the emergence of tolerably efficient voluntary agreements” (p. 69). Expanding on Coase’s (1960) original case of one cattle raiser and one farmer, Buchanan (1973) notes that, when many cattle raisers and many farmers are involved, inefficient results arise due to the “publicness” of interaction among farmers or holdout power of each farmer. Here, Buchanan makes a crucial distinction between large-scale externalities (involving lengthy multilateral negotiations) and small-size externalities (bilateral negotiations), suggesting that institutional consideration matters for situations involving multilateral negotiations.

For example, whether or not cattle-raisers have legal rights to allow animals to stray affects both the possibility of negotiation and efficiency of outcomes.

In her tribute to James Buchanan, Elinor Ostrom writes 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 (Ostrom, 2011). Solving large-scale externalities is difficult, primarily because organizing in large units is difficult. If we attempt to internalize large-scale externalities at a singular jurisdictional level, mass coordination across different layers of governments and between different institutional arrangements is required. This is far more challenging and needs a different policy approach than small-scale externalities with fewer coordination problems. Thus, large-scale externalities are not only large in the literal sense of the word, but also in a policy sense because their effects cross jurisdictional and institutional boundaries. This size factors consideration led Ostrom (2009, 2012) to advance a nested externalities framework to address large-scale externalities such as climate change and global pandemics (also see Paniagua and Rayamajhee, 2021; Rayamajhee and Paniagua, 2022; Rayamajhee et al., 2021).

4. A revised classification 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. However, if the choice of attributes is motivated by questions relating to why our reality does not concur with an idealized world characterized by zero transaction costs and a predetermined set of institutions, the resulting analysis is unlikely to serve that purpose. For any analyses of externalities and their classification to be useful for policy purposes, they must meet the two criteria that both Coase and Ostrom so craftily utilized in their works: 1) the analytical point of entry must be the externality itself, not some high-level theory, and, 2) reform proposals must be based on a comparison of performances across real institutional alternatives, not mythical ones.

In the remainder of this section, we integrate insights from Coase and Ostrom to sketch a new taxonomy of externalities that is better suited for mapping externalities to appropriate institutional

solutions. To do so, we consider the two attributes we just discussed: namely, a) the assignability and enforceability of property rights, and b) size/scale factors of externalities. The former lets us address externalities involving non-tradable rights, whereas the latter allows us to account for policy significance. While these attributes can be viewed as different types and magnitudes of transaction costs that preclude voluntary coordination or exchange (for example, see Libecap, 2014), the approach we adopt is to unbundle transaction costs along their scalar (scale/size) and institutional (property rights) dimensions – the two distinct aspects that tend to be conflated in the externalities literature.

Figure 1 presents the 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 of externalities to exist in a continuum, but we leave it trichotomized in the diagram for illustrative purposes. On the one extreme, we have small-scale externalities, either ignorable because they are of insignificant consequence or easily solvable through bilateral Coasean bargaining, market exchanges, or mutual cooperation; On the other extreme, we have large-scale externalities that require inter-jurisdictional coordination through diverse institutions such as complex markets, voluntary associations, governments, and other hybrid institutions. In between the two extremes, there 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 pertain to the number of individuals, agents, and/or their representatives directly interacting in a given collective action situation.

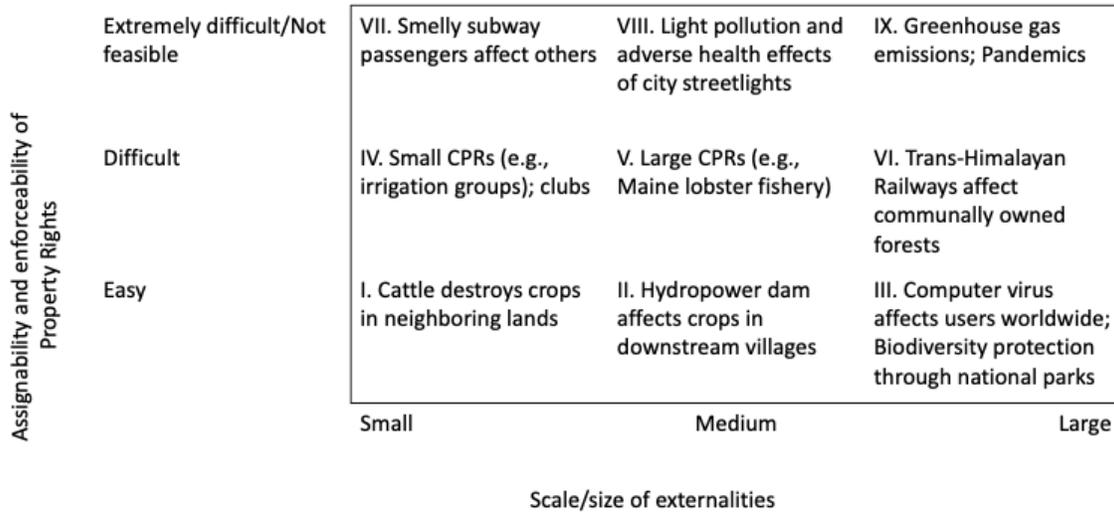


Figure 1: A taxonomy of externalities

On the vertical axis, we place the divisibility and assignability of property rights, ranging from easy to difficult to extremely difficult or not feasible. We do not represent these explicitly as (transaction) costs because of potential legal impermeability and non-tradable property rights considerations discussed in the previous section. Various factors determine the level of difficulty of assigning 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).⁶

Cases I-III in figure 1 are recognized as being relatively easy⁷ to solve – thanks to a voluminous body of work extending Coase’s pathbreaking analyses on transaction costs (for example, see Cheung, 1973; Demsetz, 1970). Case I represents a scenario when the scale of externalities is small and the tasks of assigning and enforcing property rights are easy. Take the hypothetical

⁶ Although interesting and not entirely unrelated to the topic at hand, the factors affecting property rights constitutes a large literature of its own and is not the focus of this paper. It is worth noting that many of the ‘costs’ related factors can rarely be quantified strictly in monetary terms in empirical settings involving externalities. Thus, the ‘costs’ are rather imperfect proxies for ease of difficulties of establishing and enforcing property rights to internalize externalities.

⁷ This class of externalities is ‘easy’ in a sense that one can resolve them without diverting significant public resources through collectivization schemes. Private parties can use various contracting and bargaining mechanisms, employ mediators, and so on, to establish, clarify, and/or enforce property rights. Each case might be complicated and difficult to the relevant parties involved in the process, but they are ‘easy’ for the broader community.

example introduced by Coase involving a cattle raiser and a farmer. In the example, the cattle-raiser owns straying cattle which 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 or not 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 obliged to compensate her; and, if he is rational, he will compensate her, up to the point where the marginal benefit from additional cattle grazing in the nearby farm exceeds the compensation value. If the cattle-raiser is not obliged to pay, it is in the farmer's best interest to pay the cattle-raiser not to let his animals stray on her farmland; and, a rational farmer will pay to do so, as long as the marginal benefit from crops exceeds the value of the payment. Thus, both parties have incentives to come to a mutually beneficial agreement that minimizes harm (or maximizes revenue). Other common examples of 'easy' cases of small-scale externalities include tenant-landlord relations (where a tenant's negligence leads to damages), and 'apples and bees' case (where a beekeeper benefits from the neighboring apple orchard but does not provide compensation) (Boudreaux and Meiners, 2019; Cheung, 1973; Muth et al., 2003).

Case II (figure 1) depicts scenarios where the scale of the externality is greater (and the number of affecting and/or affected parties is higher) and will thus require multi-lateral negotiations. Even then, as long as property rights can be assignable and enforceable at low costs, externalities can be tolerably internalized. An example of situation involving a medium scale externality where 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 – involving multiple farmers and the firm's stakeholders – an arrangement that satisfies both the firm's stakeholders and downstream farmers is feasible without an external intervention by external regulatory authorities. This is because property rights for both crops destroyed and hydroelectricity generated can be easily assigned and implemented; market prices for both goods are readily available, and negotiations between farmers' representatives and the firm management is possible (Rayamajhee & Joshi, 2018). Even when multiple firms are involved and number of affected farmers' increase, endogenous solutions through multilateral Coasean

bargainings remain feasible, provided there exists an institutional environment that facilitates conflict resolution.

Case III represents a scenario where the large scale presents coordination challenges. As the scale of externalities exceeds a certain threshold, Coasean bargainings become too cumbersome irrespective of the relative ease of assigning and enforcing property rights. Nonetheless, the need for countless bargainings can be circumvented by institutional and technological innovations of mechanisms of assigning and enforcing property rights. The greater scale of the problem and the relative ease with which property rights can be established and enforced create numerous possibilities. The precise ways in which the possibilities end up materializing will depend on the institutional environment and the interplay of private and public incentives. Where commerce is permitted and encouraged, private entrepreneurs may find new profit avenues by introducing tools to mitigate externalities. Computer viruses affecting users worldwide is an example of a large-scale externality which can be easily solved by private technological entrepreneurs because property rights of the associated technologies (computers, user interface) and of their solutions (anti-virus software) is easy to establish and enforce.

In situations where externality-related markets are not permitted or are unable to satisfactorily solve the problem, public and social entrepreneurs or organizations may find institutional solutions to circumnavigate 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” (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 factor, coupled with low costs of property rights assignment and enforcement, means that there exists large economies of scale and that the possibility of Pareto improvement is immense. Thus, this class of externality cases are unlikely to remain unaddressed for too long in societies with (minimally) good governance and/or vibrant markets.

Cases IV-VI represent difficult externality situations, where establishing and enforcing property rights require substantial institutional ingenuity but are nonetheless possible. A good example for case IV is a small-scale externality problem facing the 600 common pool resource (CPR) users of communally owned land in Törbel, Switzerland (Ostrom, 1990, p. 61). The communal nature of the resource systems such as grazing grounds present numerous externality challenges; 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.⁸ For example, to avoid overexploitation of the grazing grounds, they devised detailed written codes dating back to 1517 that assigns various rights and responsibilities to users and managers of the resource system. To minimize externality problem pertaining to overgrazing, they designed detailed rules stipulating appropriation rights (referred to as “cow rights”) that specified how many cows each villager could send and for how long, and how the amount of cheese each household would be eligible for during the annual distribution (ibid.). The rules are enforceable at low costs because the villagers’ have preexisting social relations and shared history that leads to high social trust; and, the codes dictating resource appropriation and maintenance are well-respected because they include mechanisms to address grievances and/or adapt the rules when equity and other concerns arise due to changing economic and environmental factors. Elsewhere, CPRs users have failed to generate self-governing institutions to sustainably manage their resources. Fishers in Mawelle, Sri Lanka (N=300), for instance, were unable to sustain entry rules controlling resource extraction, lacked effective conflict resolution mechanisms, and even resorted to violence (ibid, p. 149-150).

Case V is similar to case IV in that participants face significant but addressable difficulties in establishing and enforcing property rights. But they are different in one fundamental sense: The scale of externalities is larger in Case V – more parties are involved, and externalities often span multiple jurisdictions. Well-documented cases of offshore fisheries in the United States provide

⁸ Ostrom (1990, p. 62) notes five types of communally owned property: the alpine grazing Meadows, the forests, the “waste” lands, the irrigation systems, and the paths and roads connecting privately and communally owned properties.

good examples of medium to large scale externality problem with significant difficulties of establishing and enforcing property rights (Libecap, 1994, 2014; McGinnis, 2011; Schlager et al., 1994). Geography imposes many of these difficulties: “the areas involved are extensive and government jurisdictions overlap” (Libecap, 1994, p.576). In most cases, there is no restriction to entry and harvest, in part due to the migratory nature of many species, but also due to legal prohibition on 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 size (ibid., p. 577). This problem can lead to complex challenges such as fish habitat degradation, poor economic returns, social hardships, and so on (Grafton et al., 2008). Although successful governance is possible, it will require overcoming substantial information failures, and establishing appropriate institutions (or modify existing institutions) to address highly context specific challenges in different areas.

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

Cases VII, VIII, IX in figure 1 represent situations where the task of internalizing externalities are extremely difficult or infeasible altogether – either because the high costs of internalization relative to their benefits or due to limits in scientific knowledge or scaling technology required to implement externality mitigation at a relevant scale. For instance, situations involving small-scale externalities that are extremely difficult or costly to resolve through property rights assignment and enforcement (case VII) are not worth addressing. These include externalities where the costs of ‘internalization’ exceeds the benefits – to what James Buchanan referred to as pareto-irrelevant externalities (Buchanan, 1973; Buchanan & Stubblebine, 1962; Marciano, 2011). The costs of creating rules and establishing olfactory police to prevent smelly subway passengers from affecting their fellow passengers far exceeds the potential benefits that would be acquired from not having smelly passengers on the subway. Buchanan and Tullock’s (1962) red underwear example presumably also fits this characterization, where the solutions are not worth the potentially high decision-making and enforcement costs.⁹ As they note, “even when it is possible to remove all 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” (p. 44).

Cases 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 case VII, where the small size factor provides plausible justification for inaction, externalities represented by cases VIII and IX are sufficiently large in scale that they will not or cannot be ignored – irrespective of the magnitude of mitigation costs that may be incurred. Even when effective solutions are absent, and existing solutions do not pass the benefit-cost litmus tests, such externalities tend to garner considerable public attention and engender significant public investment towards mitigation efforts. Some of these externalities may be ‘pareto-irrelevant,’ in Buchanan and Stubblebine’s (1962) terms, because affected party (or parties) cannot be made better off without making the unaffected parties worse off. However, they are also ‘pareto-defying’ in that public sentiments and political incentives associated with medium to large scale

⁹ Buchanan and Tullock (1962) present this as a case of zero decision costs but nonzero private costs. For individuals who find red underwears repulsive and hold strong judgments about others’ undergarments, this may be an negative externality.

externalities tend to result in an outpouring of public attention and investment towards their mitigation.

A fitting illustration of case VIII externality is provided by light pollution related adverse consequences of installing streetlights in cities. Cities install streetlights because they help improve nighttime visibility, and lead to a reduction in crimes and (arguably) an increase transportation safety (Doleac & Sanders, 2015; Gerdes, 2013). However, streetlights-induced light pollution can have many direct and indirect adverse health consequences, including insomnia, obesity, and even cancer (Haim and Portnov, 2013). For instance, Jones (2018) finds that the 2009 Los Angeles (LA) LED streetlight efficiency program that installed 141,089 units of LED streetlights in LA led to an increase in breast cancer mortality of 0.479 per 100,000.

Epidemiological literature documents that artificial lights at night (ALAN) disrupts the circadian rhythm, thus leading to decreases in melatonin and increasing the risks of breast cancer (Haim & Portnov, 2013; Stevens, 2011; Yang et al., 2014). Although private citizens can adopt various measures to protect themselves from the adverse effects, such measures only work up to an extent because limiting regular exposure to streetlights is difficult. City governments could adopt other alternatives, for example by replacing LED lights with gas lamps, but that too would lead to other externalities such as an increased fire risk and methane emission. While improvements along the margins may be possible through technological innovation, permanent solution remains extremely costly and/or infeasible. Thus, city officials and citizens (taxpayers) are left to weigh the costs and benefits of different kinds of streetlight technologies and pick their externality of choice.

Finally, case IX represents externalities that are too large in scale to fall under the purview of a single overarching governing institution and too difficult to assign and enforce 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; also see Paniagua & Rayamajhee, 2021). Temptations to treat such externalities as homogeneous problems to be solved at a national or global authority are ever present, particularly amongst academic and policy circles. However, as the COVID-19 pandemic has shown, collective action challenges associated with pandemics vary widely across national and

subnational jurisdictions, cultures, and communities (Paniagua & Rayamajhee, 2021, p. 542). Thus, efforts at all governmental levels, private and nongovernmental sectors, and citizens are required to have any hopes at generating a sustainable solution. Often, measures taken to mitigate externalities of this type have a co-productive feature: they require active inputs and direct engagement from all participants (Paniagua & Rayamajhee, 2021; Rayamajhee et al., 2021)

5. Conclusion and Implications

Throughout the essay, we have argued that many new insights on externalities can be generated by incorporating Elinor Ostrom's analyses of property rights and institutional diversity into the transaction costs theory advanced by Ronald Coase others. The focus 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 and enforced to internalize it. We provided a new classification of externalities along these two oft-conflated dimensions and showed that focusing on their interaction provides a novel path forward to conceptualize externalities in a manner that accounts for institutional diversity characteristic of our polycentric society. The proposed approach adds enough nuance to account for both the intrinsic characteristics of a given externality and the institutional context within which it is embedded. Thus, it makes it possible to map out externalities to the appropriate class of institutions suited to address them and evade the futile market-versus-state conundrum (Furton & Martin, 2019; E. Ostrom, 2010; Rayamajhee & Paniagua, 2021).

We argued in the paper that neither the mere presence of externalities nor their magnitudes alone justify external intervention or governmental action to 'internalize' them and restore equilibrium. We showed that the two attributes – namely the scale component and the divisibility & assignability of property rights – jointly determine the costs and benefits of different institutional solutions and their economic viability. For each of the nine classes of externalities discussed, the degrees of costs and benefits vary based on which set of institutions is 'chosen' to reconcile them. In an institutional environment that encourages market solutions, various externality markets can emerge to tackle small to large scale externalities. Where property rights are absent or difficult to establish due to technical barriers, private firms and communities can innovate excluding

mechanisms and technology to internalize externalities up to a tolerable level. In settings where transactions are infeasible or forbidden – due to reasons such as the absence of markets, legal barriers, institutional norms prohibiting transactional relations, insurmountable costs, or lack of technology – communities can generate rules to unbundle property rights and participate in exchange processes to minimize externalities. Often governments can and do play the role of institutional-catalyst in facilitating rule generation and implementation processes. Whereas, complex large-scale externality challenges such as climate change and pandemic tend to be nested in nature (Ostrom, 2012; Paniagua & Rayamajhee, 2021). Such problems thus require nested solutions, where individual citizens, communities, private firms, nongovernmental organizations, scientific communities, and governments at various levels all have vital roles to play (Rayamajhee et al., 2021).

Externalities, much like their invocation by economists and policymakers, are ubiquitous. The facts about human sociality tell us that all our utility functions are, by definition, interdependent; and the inevitable interdependency between production functions is what makes social progress and civilization possible. Without these inter-temporal and inter-spatial interdependencies between consumers and producers, none of today's problems and achievements would be realized. In other words, our material and social progress, as well as our common challenges, are due to the ubiquitous divergence between private and social costs and benefits. Nonetheless, simply noting that private costs and benefits do not equate social costs and benefits in any given exchange relation 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, in fact, the externality must be remedied.

Nevertheless, analysts and policymakers frequently appeal to the mere presence of externalities, particularly those of the medium to large scale types (depicted by cases II, III, V, VI, VIII, and IX in the previous section) to justify active governmental intervention to modify exchange relations. The sheer enormity in scale of an externality situation, it is often argued, demands collectivization of the problem in some form. Our analysis thus far has shown that this conclusion is deficient; it skips important logical steps because it is devoid of institutional context. While institution-free analysis can be a useful first step to understand a gamut of possible incentive structures and

economic relations, policymakers do not have the privilege of implementing policies in an institution-free world. Any policy-relevant analysis, as we have discussed before, must account both for the intrinsic features of the externality as well as the details of the institutional setting within which the externality materializes.

References

- Bator, F. M. (1957). The simple analytics of welfare maximization. *The American Economic Review*, 47(1), 22–59.
- Bator, F. M. (1958). The anatomy of market failure. *Quarterly Journal of Economics*, 72(3), 351–379.
- Boudreaux, D. J., & Meiners, R. (2019). Externality: Origins and classifications. *Nat. Resources J.*, 59, 1.
- Buchanan, J. M. (1973). The institutional structure of externality. *Public Choice*, 14(1), 69–82.
- Buchanan, J. M., & Stubblebine, Wm. C. (1962). Externality. *Economica*, 29(116), 371–384.
- Buchanan, J. M., & Tullock, G. (1962). *The Calculus of Consent: Logical Foundations of Constitutional Democracy* (Vol. 3). University of Michigan Press Ann Arbor.
- Cheung, S. (1973). The fable of the bees: An economic investigation. *The Journal of Law and Economics*, 16(1), 11–33.
- Coase, R. (1992). The Institutional Structure of Production. *American Economic Review*, 82(4), 713–719.
- Coase, R. H. (1959). The Federal Communications Commission. *The Journal of Law and Economics*, 2, 1–40. <https://doi.org/10.1086/466549>
- Coase, Ronald H. (1960). The problem of social cost. *The Journal of Law & Economics*, 56(4), 87–137.
- Coase, Ronald H. (1974). The lighthouse in economics. *The Journal of Law and Economics*, 17(2), 357–376.
- Demsetz, H. (1970). The private production of public goods. *The Journal of Law and Economics*, 13(2), 293–306.
- Demsetz, H. (1996). The core disagreement between Pigou, the profession, and Coase in the analyses of the externality question. *European Journal of Political Economy*, 12(4), 565–579.

- Doleac, J. L., & Sanders, N. J. (2015). Under the cover of darkness: How ambient light influences criminal activity. *Review of Economics and Statistics*, 97(5), 1093–1103.
- Furton, G., & Martin, A. (2019). Beyond market failure and government failure. *Public Choice*, 178, 197–216.
- Gerdes, J. (2013). Los Angeles Completes World's Largest LED Street Light Retrofit. *Forbes*. Retrieved from <https://www.forbes.com/sites/justingerdes/2013/07/31/los-angeles-completes-worlds-largest-led-street-light-retrofit/>
- Grafton, R. Q., Hilborn, R., Ridgeway, L., Squires, D., Williams, M., Garcia, S., ... Zhang, L. X. (2008). Positioning fisheries in a changing world. *Marine Policy*, 32(4), 630–634. <https://doi.org/10.1016/j.marpol.2007.11.003>
- Haim, A., & Portnov, B. A. (2013). *Light pollution as a new risk factor for human breast and prostate cancers*. Springer.
- Hodgson, G. M. (2015). *Conceptualizing capitalism*. University of Chicago Press.
- Hyman, D. N. (2014). *Public finance: A contemporary application of theory to policy*. Cengage Learning.
- Jones, B. A. (2018). Spillover health effects of energy efficiency investments: Quasi-experimental evidence from the Los Angeles LED streetlight program. *Journal of Environmental Economics and Management*, 88, 283–299.
- Keech, W. R., & Munger, M. C. (2015). The anatomy of government failure. *Public Choice*, 164(1–2), 1–42.
- Leeson, P. T., & Rouanet, L. (2021). Externality and COVID-19. *Southern Economic Journal*, 87(4), 1107–1118.
- Leeson, P. T., & Thompson, H. A. (2021). Public choice and public health. *Public Choice*, 1–37.
- Libecap, G. D. (1994). The Conditions for Successful Collective Action. *Journal of Theoretical Politics*, 6(4), 563–592. <https://doi.org/10.1177/0951692894006004007>
- Libecap, G. D. (2014). Addressing global environmental externalities: Transaction costs considerations. *Journal of Economic Literature*, 52(2), 424–479.
- Lucas, P. S., Carvalho, R. G. de, & Grilo, C. (2017). Railway disturbances on wildlife: Types, effects, and mitigation measures. In *Railway ecology* (pp. 81–99). Springer, Cham.
- Marciano, A. (2011). Buchanan on externalities: An exercise in applied subjectivism. *Journal of Economic Behavior & Organization*, 80(2), 280–289.

- McGinnis, M. D. (2011). Networks of adjacent action situations in polycentric governance. *Policy Studies Journal*, 39(1), 51–78.
- Meade, J. E. (1952). External economies and diseconomies in a competitive situation. *The Economic Journal*, 62(245), 54–67.
- Medema, S. G. (2020a). “Exceptional and Unimportant”? Externalities, Competitive Equilibrium, and the Myth of a Pigovian Tradition. *History of Political Economy*, 52(1), 135–170.
- Medema, S. G. (2020b). The Coase theorem at sixty. *Journal of Economic Literature*, 58(4), 1045–1128.
- Muth, M. K., Rucker, R. R., Thurman, W. N., & Chuang, C.-T. (2003). The fable of the bees revisited: Causes and consequences of the US honey program. *The Journal of Law and Economics*, 46(2), 479–516.
- Ostrom, E. (1968). Some postulated effects of learning on constitutional behavior. *Public Choice*, 5(1), 87–104.
- Ostrom, E. (1986). An agenda for the study of institutions. *Public Choice*, 48(1), 3–25.
- Ostrom, E. (1990). *Governing the Commons*. Cambridge University Press.
- Ostrom, E. (2003). How types of goods and property rights jointly affect collective action. *Journal of Theoretical Politics*, 15(3), 239–270.
- Ostrom, E. (2009). *A polycentric approach for coping with climate change*. The World Bank.
- Ostrom, E. (2010). Beyond markets and states: Polycentric governance of complex economic systems. *American Economic Review*, 100(3), 641–672.
- Ostrom, E. (2011). Honoring James Buchanan. *Journal of Economic Behavior & Organization*, 80(2), 370–373.
- Ostrom, E. (2012). Nested externalities and polycentric institutions: Must we wait for global solutions to climate change before taking actions at other scales? *Economic Theory*, 49(2), 353–369. <https://doi.org/10.1007/s00199-010-0558-6>
- Ostrom, V., & Ostrom, E. (2002). Public Goods and Public Choices. In M. Michael D. (Series Ed.), *Institutional Analysis. Polycentricity and Local Public Economies: Readings from the Workshop in Political Theory and Policy Analysis* (pp. 75–103). Michigan-Ann Arbor: The University of Michigan Press.

- Paniagua, P., & Rayamajhee, V. (2021). A polycentric approach for pandemic governance: Nested externalities and co-production challenges. *Journal of Institutional Economics*, 1–16.
- Papandreou, A. A. (1998). *Externality and institutions*. Oxford University Press.
- Rayamajhee, V., & Joshi, A. (2018). Economic trade-offs between hydroelectricity production and environmental externalities: A case for local externality mitigation fund. *Renewable Energy*, 129, 237–244. <https://doi.org/10.1016/j.renene.2018.06.009>
- Rayamajhee, V., & Paniagua, P. (2021). The Ostroms and the Contestable Nature of Goods: Beyond Taxonomies and Toward Institutional Polycentricity. *Journal of Institutional Economics*, 17(1). <https://doi.org/10.1017/S1744137420000338>
- Rayamajhee, V., & Paniagua, P. (2022). Coproduction and the Crafting of Cognitive Institutions during the COVID-19 Pandemic. *Journal of Institutional Economics*.
- Rayamajhee, V., Shrestha, S., & Paniagua, P. (2021). Governing nested externalities during a pandemic: Social distancing as a coproduction problem. *Cosmos+Taxis*, 9(5+6), 64–80.
- Samuelson, P. A. (1954). The pure theory of public expenditure. *The Review of Economics and Statistics*, 387–389.
- Schlager, E., Blomquist, W., & Tang, S. Y. (1994). Mobile flows, storage, and self-organized institutions for governing common-pool resources. *Land Economics*, 294–317.
- Schlager, E., & Ostrom, E. (1992). Property-rights regimes and natural resources: A conceptual analysis. *Land Economics*, 249–262.
- Scitovsky, T. (1954). Two concepts of external economies. *Journal of Political Economy*, 62(2), 143–151.
- Stevens, R. G. (2011). Testing the light-at-night (LAN) theory for breast cancer causation. *Chronobiology International*, 28(8), 653–656.
- Tullock, G. (1998). Externalities and government. *Public Choice*, 411–415.
- Yang, W.-S., Deng, Q., Fan, W.-Y., Wang, W.-Y., & Wang, X. (2014). Light exposure at night, sleep duration, melatonin, and breast cancer. *European Journal of Cancer Prevention*, 23(4), 269–276.