

**A History of Pricing Pollution**  
**(Or, Why Everything You Thought You Knew About it is Wrong**  
**and Pigouvian Taxes are not Necessarily Pigouvian)**

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## **1. Introduction**

From the publication of Rachel Carson's *Silent Spring* in 1962 to the first Earth Day in 1970, the 1960s witnessed a turning point in environmental thinking and politics. Social and political movements turned from the conservation of natural resources needed for production to a new post-war focus on the good life and aesthetic consumption (Hays 1982, 1987). Contemporaneously, economists turned from comprehending their own discipline in terms of "material welfare," to comprehending it in line with Lionel Robbins's definition in terms of tradeoffs and opportunity costs (Backhouse and Medema 2009a,b). This turn created space to redefine the relationship between economics and the environment to account for households' values for preservation, however immaterial or "spiritual" they might be, as the idea of "consumption" became ever broader and more abstract (Banzhaf 2019).

Numerous economists jumped into this space, from Robert Solow and Joseph Stiglitz to Kenneth Boulding and Nicholas Georgescu-Roegen on questions of sustainability, from Kenneth Arrow to James Buchanan on externalities, or William Baumol, Wallace Oates, and Martin Weitzman on pollution pricing, among many others. But of all economists working on pollution pricing in the era, Allen V. Kneese (1930-2001) was the widely acknowledged leader. In *The Economics of Regional Water Quality Management* (1964), Kneese, an economist at Resources for the Future, introduced detailed proposals for "effluent charges" on emissions of pollutants into waterways. Shortly thereafter, Thomas Crocker (1966) and John Dales (1968a,b) introduced proposals for trading pollution rights, later known as the tradable permit or cap-and-trade approach.

The conventional narrative is that such work picked up where A.C. Pigou had left off some 30 years before in *The Economics of Welfare* (1932) (Berta 2019, Pearce 2002, Sandmo 2015, de Steiguer 2006). According to this way of thinking, Pigou had developed his theory of external

economies and diseconomies in the first third of the 20<sup>th</sup> Century using environmental as well as other examples. Though the idea lay neglected for some decades, when economists began to take up environmental issues in the late 1950s and 1960s, they picked up Pigouvian models and policy tools (the familiar "Pigouvian tax") to address them. A corollary to this theory is that Ronald Coase's "Problem of Social Cost" (1960) was an early response to this trend, introducing a rival approach of property rights and trading in lieu of corrective pricing. Environmental economists and their policy proposals can then be classified by the extent to which they are Pigouvian or Coasean or some hybrid.

In this paper, I argue that, while this Pigouvian box was undeniably an important source for economists in the 1960s thinking about externalities, it was but one of many. Nobody likes neat boxes, and it is cheap work historically to blur their boundaries, but logical categories are necessary. My claim here is not just that the "Pigouvian" and "Coasean" boxes are too neat, but that we have missed entire boxes altogether, and perhaps the ones at eye level on the shelf. In the US, first-generation specialists in environmental economics had been trained in agriculture and natural resources and/or in regional development, fields which had their own well-established canon covering questions of land use, property rights, indivisibilities, incentives, and so forth, much of it with an American institutionalist stamp. Trying to understand such work in terms of old debates between Cambridge and LSE is a categorical mistake.

As Medema (2020a) has recently emphasized, one problem with the conventional narrative is that it's impossible to trace an unbroken line from Pigou to the environmental work of the 1960s. In the intervening decades, Pigou's ideas on external (dis)economies had evolved into today's concept of externalities, but without much reference to real-world applications. As Medema tells the story, the line was lost but then reconnected: When environmental applications began to loom larger, the revised Pigouvian theory was simply "grafted into" the emerging field of environmental economics. In this paper, I offer a different explanation. In the first half of the 20<sup>th</sup> Century, Pigou's ideas about the divergence between the private value of investments and social net product, though important, never really were as unique as the later literature came to imply. In fact, there *were* continuous lines of thought running through the period in American economics, but the lines run back to the economics of land use and resource development, not to Pigou. Though the *moniker* "Pigouvian" was adopted around 1970, it should not be confused with hereditary lineage.

Section 2 of this paper gives an overview of Pigou's discussion of social benefits and costs as well as the secondary literature that has by now well established the difficulties with linking his work to the emerging field of environmental economics in the 1960s. Section 3 introduces the work of Allen Kneese, the leading expert in the era on pollution pricing, and discusses its relationship to Pigou, Coase, and other sources; Section 4 similarly introduces the work of Thomas Crocker and John Dales on tradable pollution rights. Section 5 situates their work in the historical context of agricultural and applied resource economics.

## 2. The Pigouvian Tradition

The standard history of environmental economics begins with the work of A.C. Pigou (1877 - 1959), the Cambridge economist famous for his theory of the potential divergence between private benefits and costs (values that could be captured by markets) and social benefits and costs.<sup>1</sup> Following Bator (1957, 1958), economists today would refer to these effects—especially as they relate to environmental problems—as "externalities." Externalities are famously hard to define, but, roughly speaking, they represent an effect on third parties, uninvolved in an economic transaction or decision.<sup>2</sup>

In *The Economics of Welfare* (1932), Pigou identified three groupings of situations where he thought there is a divergence between private and social benefits and costs. Pigou's second grouping is the one closest to what we now think of as externalities. This represents a situation where

One person A, in the course of rendering some service, for which payment is made, to a second person B, incidentally also renders services or disservices to other persons . . . , of such a sort that payment cannot be exacted from the benefited parties or compensation enforced on behalf of the injured parties. (p. 183)

Pigou gives several examples of such services that certainly could be read as a kind of proto-environmental economics. "Uncompensated services are rendered," he says,

when resources are invested in private parks in cities; for these, even though the public is not admitted to them, improve the air of the neighbourhood. The same

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<sup>1</sup> For background, see Medema (2009, Ch. 3), Aslangeigui and Oakes (2015), and Kumekawa (2017).

<sup>2</sup> Classic attempts to wrestle with the definition of externalities include Viner (1932), Meade (1952), Scitovsky (1954), Bator (1958), Buchanan and Stubblebine (1962), and Arrow (1969). For historical overviews of the concept, see Papandreou (1994), Lagueux (2010), Berta (2017), and Medema (2020a).

thing is true—though here allowance should be made for detriment elsewhere—of resources invested in roads and tramways that increase the value of the adjoining land. . . . It is true, in like manner, of resources devoted to afforestation, since the beneficial effect on climate often extends beyond the borders of the estate owned by the person responsible for the forest. . . . It is true of resources devoted to the prevention of smoke from factory chimneys: for this smoke in large towns inflicts a heavy uncharged loss on the community, in injury to buildings and vegetables, expenses for washing clothes and cleaning rooms, expenses for the provision of extra artificial light, and in many other ways. (p. 184)

Pigou gives other examples as well, including Mill's example of a lighthouse aiding ships; private lamps at house doors, which illuminate the street; and basic scientific research. Thus, Pigou's discussion seems like a natural source for economic thinking about environmental problems.

Though Pigou's importance to environmental economics cannot be denied, a story about environmental economics being developed through applications of Pigou's theory of externalities runs into three difficulties. First, Pigou's analysis was much wider ranging than today's theory of externalities. As already noted, he considered three groupings of effects. The first includes situations where productive investments might potentially be made by people who do not own the instrument of production being maintained or enhanced. A notable example is tenant farmers, who do not have the full incentive to enhance the fertility of the land they are renting; indeed they have an incentive to let it depreciate rapidly in the years before their lease expires (Pigou 1932, pp. 174-83).

Pigou's third grouping comprises situations, discussed earlier by Alfred Marshall, where there are increasing or decreasing returns at the industry level or even between industries (pp. 213-28). This portion of Pigou's theory was the most controversial, and Pigou steadily revised his analysis, retreating from some of the stronger versions of the argument that he had espoused earlier in his career (McDonald 2013, Aslanbeigui and Oakes 2015). Even so, in the fourth edition of *The Economics of Welfare* (1932), Pigou gives the example of the cotton industry, which when it operates on a larger scale takes on a structure of increasing specialization among firms, with some firms weaving and some spinning, some spinning fine counts and others coarse. In such cases, he argued, investment enters the industry to the point where the marginal firm is indifferent to entering, but nevertheless its entrance increases economic rents for other firms, thus creating a divergence between the private value of investment and the social net product.

Pigou's work spawned a large literature sorting out the nuances of these three situations

and how they inter-relate.<sup>3</sup> While this is not the place to focus on the subtleties of those relationships, it is enough for my purposes to highlight the fact that, taken as a whole, Pigou's discussion did not, at the time, obviously apply to environmental problems.

The second difficulty with a linear history from Pigou to modern environmental economics is that, as emphasized previously by other observers, while it is the second of Pigou's groups that today is most closely associated with the idea of "externalities," that actually was the group most ignored in the literature until at least the late 1950s, with passing references to smoking chimneys or traffic congestion viewed as "curiosities" or, in Baumol's (1952) words, "freakish exceptions."<sup>4</sup> Two decades later, with environmental economics on a swift ascent, Kneese commented:

Environmental pollution has existed for many years in one form or another. It is an old phenomenon, and yet in its contemporary forms it seems to have crept up on governments and even on pertinent professional disciplines such as biology, chemistry, most of engineering, and, of course, economics. A few economists, such as Pigou, wrote intelligently and usefully on the matter a long time ago, but generally even that subset of economists especially interested in externalities seems to have regarded them as rather freakish anomalies in an otherwise smoothly functioning exchange system. Even the examples commonly used in the literature have a whimsical air about them. We have heard much of bees and apple orchards and a current favorite example is sparks from a steam locomotive—this being some eighty years after the introduction of the spark arrester and twenty years after the abandonment of the steam locomotive. (1971 p. 2)

In other words, there was a large gap between the time Pigou wrote about what we would now call externalities and references to it in the literature, at least those that took it seriously. This gap raises the possibility that other currents were at work during the period.

The third—and most surprising—difficulty with the Pigouvian narrative is that until about 1970 the environmental and natural resource literature hardly referenced Pigou at all. When economists in the 1960s did refer to Pigou in the context of environmental problems, it was usually limited either to welfare economics very broadly or to Pigou's discussion of our defective telescopic faculty and the resulting excessively rapid depletion of natural resources.<sup>5</sup> On the other

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<sup>3</sup> For discussion, see Lagueux (2010), McDonald (2013), Berta (2017), and Medema (2020a).

<sup>4</sup> See Lagueux (2010), Lane (2014), Sandmo (2015), and especially Medema (2020a).

<sup>5</sup> E.g., Krutilla 1967. See Collard (1996) and Kula (1998 Ch. 6) for historical discussion of Pigou's views on resource depletion.

hand, when they discussed notions that resemble environmental "externalities," economists hardly referenced Pigou. Even more to the point, they rarely mentioned him when discussing pricing access to environmental resources, not only for "green" uses like recreation, but even for "brown" uses like depositing wastes. Though today economists might naturally refer to such prices as "Pigouvian taxes," at the time they were known simply as "effluent charges" (e.g. Kneese 1964), without making a connection to Pigou. As I show in the next section, the Pigouvian terminology entered widespread circulation in the 1970s.

Of course, one possible reason economists might not have attributed their ideas to Pigou is that his ideas had become so embodied in economics, so taken for granted, that they did not warrant citations.<sup>6</sup> However, as I show in the following sections, the style of argument used by first-generation environmental economists, along with the hints from those references they do make, suggest there is more to the story. The lacunae suggest the possibility that pollution pricing had links to other traditions besides the Pigouvian one.

### **3. Allen Kneese and Effluent Charges**

In the 1960s, Allen V. Kneese (1930-2001) was the widely acknowledged leader in the economics of pollution pricing.<sup>7</sup> Extensively cited, Kneese's *Economics of Regional Water Quality Management* (1964) and other works were considered the first systematic treatment of the topic and certainly the most definitive.<sup>8</sup>

Kneese earned his PhD in economics from Indiana University, with a dissertation on market power and exclusive dealing in the farm machinery, automobile, and petroleum industries (Kneese 1956). After graduating, he worked at the University of New Mexico and at the Federal Reserve Bank of Kansas City, where he first turned to researching water resources problems in the American West. At what was still an early stage in his career, Kneese moved to Resources for the

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<sup>6</sup> Medema (2020a) discusses some evidence in support of the idea of an "oral tradition" as mentioned by Coase (1960).

<sup>7</sup> See Nishibayashi (2019) for a historical discussion of Kneese and his work.

<sup>8</sup> Fort et al. (1959) presented an earlier proposal for a "smog tax," published as a RAND report, but it did not circulate widely and appears to have been forgotten until its rediscovery ten years later. For those interested in trivia, the report was the first "publication" for both William Niskanen and William Sharpe.

Future (RFF) in 1961.<sup>9</sup> As environmental economics, alongside other sub-disciplines, was formalizing its institutions, Kneese was front and center, serving as the first president of the Association of Environmental and Resource Economists and founding editor (along with his collaborator, Ralph d'Arge) of its flagship publication, the *Journal of Environmental Economics and Management* (JEEM). Earlier, in 1965, he was also a founding editor of *Water Resources Research*.

Kneese's first forays into the economics of water resources addressed the traditional problem of developing them as inputs into material production, particularly in the context of water shortages in the American West (Kneese 1960). Like other works at the time on this surging subject, Kneese adopted a welfarist perspective on the problem, discussing "normative problems in the evaluation of water resources development projects."<sup>10</sup> As a logical point of departure, he began with what he characterized as Pigouvian welfare economics, essentially the interpretation of market prices as marginal social values generally, as in Pigou's national dividend, but not the divergence of private and social values specifically. But then Kneese's next move was to dismiss this older Pigouvian approach as too simplistic in its treatment of interpersonal comparisons of utility, now being superseded by the "new welfare economics" of Hicks and others.<sup>11</sup>

Kneese also identified Pigouvian external economies as a key concept in normative project evaluation, but only as refined by Ellis and Fellner and others. Interestingly, at this stage he barely mentioned pollution in connection to this idea. Instead, he emphasized external economies (more so than diseconomies) from increasing the scale of resource development. For example, surface-water irrigation might recharge aquifers used by neighboring farms for irrigation; upstream storage improves the efficiency of down-stream hydro-electric power; etc. Most generally, an expanding market in a rural area may contribute to an increase in regional economic efficiency by facilitating the division of labor (1960 pp. 311-12).

It was around this time that Kneese moved to RFF. As discussed in Banzhaf (2019), RFF was evolving at this time from its initial emphasis on the scarcity of natural resources needed for

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<sup>9</sup> See Kneese (1988) for a brief autobiographical statement, including a summary of early intellectual influences.

<sup>10</sup> E.g. Eckstein 1958, Krutilla and Eckstein 1958, McKean 1958, Hirshleifer, De Haven, and Milliman 1960.

<sup>11</sup> Likewise, John Krutilla, Kneese's long-time RFF colleague, depicted his own career retrospectively as having played out against the backdrop of just these issues (Krutilla 1981).

development and economic growth to a new one on the scarcity of environmental amenities. Hired by John Krutilla and Irving Fox, Kneese joined RFF as part of this pivot, leading up a new research program on water quality.

After his move to RFF, Kneese turned immediately to the study of water pollution, publishing initial thoughts on the subject (Kneese 1962, Kneese and Nobe 1962). Kneese wanted to apply a welfarist, benefit-cost perspective on the pollution problem, but he also wanted to forego the traditional approach of evaluating a policy already formulated by engineers into one that embeds the economics into the *design* multipurpose development of entire river systems. In this, Kneese was following recent trends including work by his RFF colleague John Krutilla (Krutilla and Eckstein 1958) and especially by the Harvard Water Program (Maass et al. 1962), which Kneese later singled out as the "apogee" of work on the design of multiple use water systems (Kneese 1988).<sup>12</sup>

Kneese identified several characteristics of water resources that raised unique policy problems, including, among others:

1. Water resources are highly mobile and highly variable in quantity and quality in time and space, so water quality must be treated probabilistically;
2. They do not respect political boundaries;
3. They have multiple purposes, provided by the same resource simultaneously and/or sequentially;
4. A particular use provides benefits and imposes costs on different groups separated geographically;
5. They are (at least nominally) publicly owned

(Kneese and Nobe 1962 pp. 46-7). According to Kneese, distortions from the marginal-benefit-equals-marginal-cost rule arise because, given these realities, private producers cannot enter the market and produce socially desirable value while still covering their costs. Economies of scale, indivisibilities in jointly supplied outputs, and external economies and diseconomies all impede the potential to collect sufficient revenue. Examples of such external effects include the recharging of aquifers resulting in land drainage problems; decreases in dissolved oxygen resulting in fish kills; hydroelectric power altering stream flow, which in turn hinders navigation; and irrigation

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<sup>12</sup> See Banzhaf (2009) for further discussion of the Harvard Water Program and its relationship with RFF.



which results in sedimentation of water, thereby increasing treatment costs for municipalities. Thus, whereas Kneese's RFF colleague Marion Clawson wrestled with how to think about measuring benefits of investments in public lands, in a paradigm where norms were determined by the revenues that could be raised in a realistic market institution (Banzhaf 2010a), here Kneese thinks about the problem in reverse: how realistic revenues fail to capture the normative benefits, as determined outside the market by an economic model of optimization.

In Kneese's view, all this creates a role for planning, but logically consistent plans would require two forms of aggregation. First, geographically, the planning area must be sufficiently wide to encompass these and other relevant effects, so that upstream and downstream tradeoffs were captured in the planner's field of vision. Second, to trade off the competing ends of water resources (e.g. for deposition of wastes upstream or recreation downstream), one would have to aggregate across services. Obviously, Kneese argued, one cannot maximize a mix of different services measured in incommensurate physical units. So "the question of weighting alternate physical outputs in some meaningful commensurable manner inevitably arises and the weights logically must represent some measure of relative social worth" (p. 449). If pollution damages and abatement costs both are denominated in dollars, then marginal costs can be equated across abatement alternatives and to marginal damages of foregoing abatement. This could be achieved through "a system of charges and bounties" (p. 459).

This system of effluent charges, mentioned only in passing in 1962, evolved into the centerpiece of Kneese's best-known work, *The Economics of Regional Water Quality Management* (1964), which was further expanded and revised in collaboration with Blair Bower, an engineer, in 1968 as *Managing Water Quality: Economics, Technologies, Institutions*. This work was perceived at the time to be the definitive statement of pollution pricing. As indicated by the subtitle of the 1968 book, at the outset it is evident that Kneese combined (i) the economic logic of external diseconomies and property rights; (ii) a materials balance logic of production, residual wastes, and transport of those wastes across space; and (iii) institutional concerns. As he wrote in the introduction of *Regional Water Quality Management*,

[The] economic institutions on which we customarily rely to balance costs and returns—the interaction of market forces in a private enterprise system—do not perform this function satisfactorily for waste disposal. Aesthetic nuisance in a stream destroys public values that are not marketable. In deciding how to dispose of its wastes, an upstream firm or city is not forced to take into account the costs imposed

upon downstream water users.... Under some circumstances there are economies of scale in waste disposal that cannot be realized by an individual firm or city acting independently.

Because of these features of waste disposal, market forces are supplemented in a variety of ways. Appeals are made to civic responsibility.... Damaged parties may resort to adversary proceedings in courts of law. Financial inducements to encourage waste treatment by municipalities are offered by the federal government, and storage to augment low flows is provided at federal expense. .... But in the application of these practices there has not been a systematic balancing of costs and returns to achieve optimum benefits.... (p. 4)

In short, when market institutions fail to equate marginal costs and benefits of an activity, other institutions must take their place. But so far, he said, the array of regulatory responses, while perhaps moving the outcome in the right direction, were not efficient.

Kneese's preferred solution was a system of spatially differentiated effluent charges, ideally set at the marginal damages of emissions.<sup>13</sup> Although he was optimistic about progress being made in the nonmarket valuation of pollution damages, especially in the area of outdoor recreation (see Banzhaf 2010a, 2018) and environmental health (e.g. Weisbrod 1961), Kneese acknowledged that it was not yet practical to estimate the marginal damages from pollution. Accordingly, he also considered the alternative of ambient quality standards, in which the authority mandates a minimum level of water quality to be maintained. Discussing the duality between prices and quantities, he argued that the standard could be best met by charging fees equal to the marginal costs of meeting the standard. Although not equating them to marginal damages, this more pragmatic approach would still have the virtue of equating the marginal costs of abatement across various margins of adjustments (reductions in the output of dirty goods, changes in the production process, end-of-pipe controls, water storage and dilution, etc.). Kneese proposed a trial-and-error approach that, essentially, involved groping for the unknown "supply" of pollution abatement. That is, the regulator would impose an initial price on pollution emissions (effluent), observe how much pollution was reduced at various downstream points, and then adjust the price to meet the target.

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<sup>13</sup> Kneese also considered subsidies (or bounties) for pollution abatement as an option, but felt it raised additional implementation issues. For example, if under optimal resource allocations a firm reduced its pollution by exiting the market, the owners of that non-existent firm would still have to receive their subsidy. The extent of the symmetry between pollution taxes and subsidies became an active research question around this time. See Baumol and Oates (1975) for a literature review from the period and summary.

From his discussion, it might appear that Kneese's vision was a grand plan requiring the superior knowledge of a social planner, including marginal damages and marginal abatement costs across various activities all spatially differentiated. In fact, Kneese disavowed any such interpretation. To the contrary, he stressed the fact that with effluent charges, the market—not a planner—would find the way to reduce pollution (or just pay the charge if pollution reductions were too expensive). In a static world of given abatement costs, the charges provided the incentive for firms to select those abatement technologies that were most cost-effective. In the long run, they provided dynamic incentives to find new ways to reduce pollution at lower cost.

Applications using Kneese's approach soon followed. Edwin Johnson (1967) employed a linear program to find the least-cost solution of achieving water quality standards in the Delaware estuary, given abatement cost functions and a source-receptor matrix relating effluent released at one point in the estuary (the source) to water quality effects at various down-stream points (receptors). Relative to this hypothetical least-cost solution, he found that the conventional uniform effluent standard cost 62% more to achieve a moderate ambient quality standard. In contrast, a spatially homogenous effluent charge would only cost 12% more and furthermore distribute the costs more equitably, while a zone-specific charge would only cost 7% more (p. 297, Table 1). Thus, even if it was not literally possible to equate marginal costs of abatement across all sources of effluent, charges were still much more efficient than traditional regulations on emissions.

Robert K. Davis (1968) similarly employed a linear program to find least-cost solutions for pollution reductions in the Potomac River basin. Critiquing an Army Corps of Engineers plan that had relied on constructing 16 reservoirs to store water to dilute pollution during times of low flow, Davis found a wide range of marginal costs across options, many of them much cheaper. This analysis supported Kneese's basic argument that, to achieve environmental improvements, policymakers should not try to pick preferred technologies. Even if one demurred at his actual estimates, Davis's deeper point was to demonstrate how wide ranging they could be across technologies, and thus the potential gains markets could realize when given the proper incentives.

### *Effluent Fees and Pigouvian Taxes*

Viewing the history of economics in retrospect, it is natural to interpret Kneese's effluent fees as a straightforward application of Pigouvian remedies to market failures, albeit one rich in its technical and institutional details (Berta 2019, Pearce 2002, Sandmo 2015, de Steiguer 2006). But, as

already noted, that perspective raises the question of, first, why there a large lacuna in the supposed Pigouvian literature on environmental externalities from the 1930s to '60s and, second, why, when it supposedly re-appeared, Pigou was not actually mentioned much.

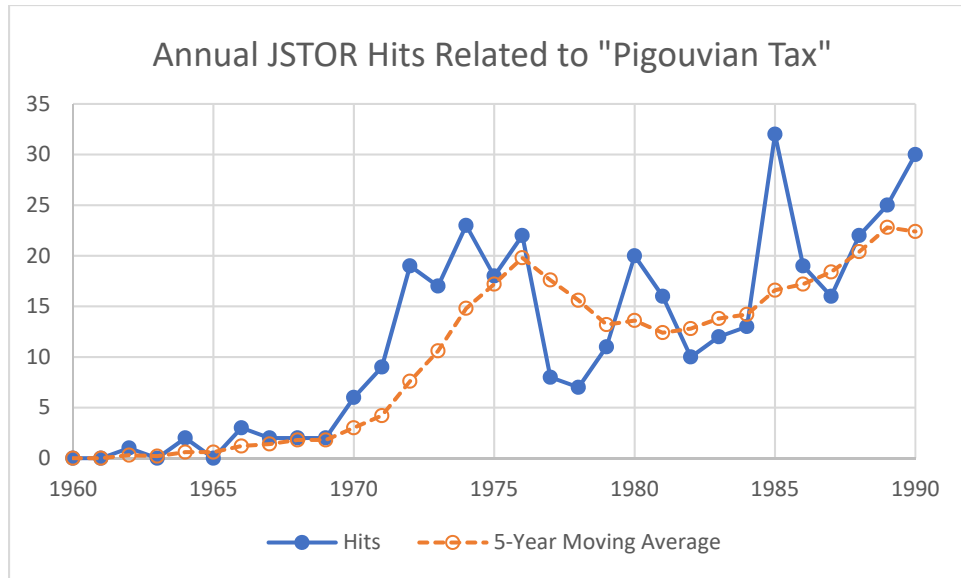
Kneese's work epitomizes these gaps between Pigou and pollution pricing. After his discussion of normative problems in evaluation of water development problems (Kneese 1960), which discussed Pigouvian welfare economics as a stage in utilitarian thinking generally, Kneese did not cite or mention Pigou at all until the end of the decade. Kneese was not alone in this. According to JSTOR, the term "Pigouvian tax" (or close variants<sup>14</sup>) appeared first in Buchanan and Stubblebine (1962) and only 12 times in the decade of the 1960s. Nor can this be attributed to a general disinterest in the topic. Until about 1972, others working on similar topics or commenting on policy proposals to levy fees on pollution—from Nobel laureates to applied practitioners—cited Kneese without mentioning Pigou, apparently treating his work as original. A Google Scholar search yielded only 65 hits mentioning Kneese *and* Pigou between 1962 and 1972, 982 hits mentioning Kneese but *not* Pigou, and 2,110 mentioning Pigou but not Kneese.<sup>15</sup> So it appears that Kneese's work on effluent charges was living out an intellectual life quite distinct from the Pigouvian literature.

At the turn of the decade, the term "Pigouvian tax" appeared in Baumol's review of Buchanan's *Cost and Choice* and in Baumol and Oates (1971). In that paper, Baumol and Oates provided a formal proof of Kneese's argument that an effluent fee could induce the least-cost method for meeting an arbitrary environmental objective, even if it was not optimal in the sense of equating marginal costs to marginal damages (see Berta 2019 for discussion). In doing so, they described Kneese's work as part of a "Pigouvian tradition." At this point, references to Pigou increased rapidly (see figure). Thus, the idea that pollution prices are almost synonymous with "Pigouvian" may have been a reinterpretation or new connection made, first by Coase and

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<sup>14</sup> Including "Pigovian" instead of "Pigouvian," "taxes" as well as "tax," and "Pigou" in conjunction with "corrective tax" or "effluent fee" or "effluent charge."

<sup>15</sup> Examples of prominent papers or authors citing Kneese but not Pigou include Crocker (1968), Dales (1968a,b), Davis (1968), Freeman and Haveman (1972), Johnson (1967), Mills (1966), Montgomery (1972), Ostrom and Ostrom (1965), and Solow (1972). The search was conducted on May 28, 2020 and excluded hits where Kneese was author or editor.



Buchanan, and then consolidated by Baumol and Oates.<sup>16</sup> By the end of the decade, Kneese himself was putting it in these terms (Ayres and Kneese 1969, Kneese and Mäler 1973) and it was enshrined in textbooks and prominent literature reviews (Baumol and Oates 1975, Fisher and Peterson 1976).

Rather than talk about his approach as Pigouvian, Kneese was, ironically, more apt to talk of it in Coasean terms (Nishibayashi 2019). In *Regional Water Quality Management*, his opening moves in his economic analysis (after a chapter on "technical and engineering facts") were to take the reader through a tour of market efficiency, with external diseconomies presenting a potential exception to the superiority of markets. He then quickly introduced the Coase theorem (Coase 1960) as one possible way for markets to consider downstream costs of waste disposal (pp. 40-47), making this one of the first treatments of the Coase theorem in the environmental economics literature.<sup>17</sup> Interestingly, Kneese interpreted the Coase theorem in terms of Coase's earlier logic from the "Nature of the Firm" (Coase 1937). Wrote Kneese,

When such technological links are "internal" to a decision unit, the result may be considerably different than if they are external. To take a simple example, a farmer may find that a small stream on his property will irrigate either an upstream plot A or a downstream plot B, but not both. .... In deciding whether to irrigate plot A,

<sup>16</sup> Medema (2020a) suggests that, ironically, it was perhaps Buchanan's and Coase's attacks in the 1960s on Pigouvian economics that built up the idea that the approach was inherently Pigouvian.

<sup>17</sup> See Medema (2014a,b, 2019, 2020b) on the Coase theorem in the environmental economics literature of the 1960s and '70s, including Kneese's role.

the farmer will consider the return lost on plot B, and plot A will be irrigated only if its return is higher. Consequently, the resource will be allocated in the way that maximizes the value of production. If, however, plot B is on another farmer's land and the owner of plot A cannot sell his right to the water, the owner of plot A will not consider the return lost on plot B in determining whether to irrigate plot A. If plot B actually presents the superior productive opportunity, failure to irrigate it because the water is preempted upstream is a technological external diseconomy.

Now suppose that the owner of plot A *can* sell his right to the water and that the farmer owning plot B can afford to, and has an incentive to, pay more for the water than it is worth if applied on plot A. In this case, the efficient result would once again be produced. (p. 41)

In this way, Kneese believed the question of external diseconomies is intrinsically intertwined with questions of property rights and market institutions, so it cannot be examined solely through technical relationships. Erstwhile diseconomies can be internalized either through negotiation (Coase 1960) or through merger (Coase 1937), but either way the logic is similar.<sup>18</sup>

Because of high transactions costs, Kneese thought that the Coase theorem, per se, was unlikely to be relevant to water pollution problems. He also thought that the idea of a single firm internalizing all the services provided by water within a relevant drainage basin was as undesirable as it was unrealistic. Operating so many enterprises would have high administrative costs. Additionally, the benefits of internalizing externalities would be at least partially offset by the creation of monopoly power.

Nevertheless, Kneese found this notion of the basin-wide firm to be useful as an organizing principle, and it was an idea he would continue to revisit throughout his career (e.g. Kneese and Schultze 1975). As with the single farm with plots A and B, Kneese suggested the basin-wide firm would be a "natural decision unit" in the sense that it would internalize externalities. It could own upstream plants that benefit from releasing wastes, but also charge levies for downstream recreation use. Then the firm will equate the marginal costs of pollution control at the upstream plants to one another, but also to the marginal damages of effluent on foregone recreation values. In making this point, Kneese drew explicitly on Coase (1937) as well as Stigler (1946) and Davis

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<sup>18</sup> See Bertrand (2015), for the connections between Coase's two classic articles; her discussion is highly pertinent to Kneese's treatment.

and Whinston (1962).<sup>19</sup>

Kneese drew three lessons from this artifice of the basin-wide firm. First, administrative agencies ideally would operate at the geographic scale of the water basin. In this way, agencies would have jurisdiction over the relevant external effects. Second, they should think in terms of economic incentives, such as those provided by effluent charges. Third, like a firm, they should think in terms of maximizing economic value, by minimizing costs and making economic tradeoffs between upstream and downstream activities. In this sense, Kneese was extending the logic of Coase's theory of the firm, but whereas Coase limited the institutional choice to either expanding the boundaries of the firm or trading among firms, he enlarged it to include regulatory agencies with their own optimal boundaries *and* the ability to change the terms of trade among firms.

Kneese was no more Coasean than he was Pigouvian. My point is not to place him in the Coasean box instead of the Pigouvian one, but to suggest that, when we see (i) that the quintessential texts on effluent fees from the period do not even mention Pigou, (ii) that they spend more time talking about Coasean models, and yet (iii) that they relate those models to decidedly non-Coasean policy remedies, then we should begin to suspect that more is going on here than a simple Pigouvian-Coasean dichotomy. In Section 5, I will return to an alternative interpretation. For now, I will limit the implications to three things that Kneese's analysis of the basin-wide firm reveals about his work.

First, Kneese thought in terms of rich and detailed political, legal, and economic institutions. Ideas like external diseconomies were not just technological relationships, they were embedded in social relationships, which required a comparative analysis of which institutions could deliver more value. Kneese combined microeconomic theory with detailed case studies, such as his study of the *Genossenschaften*, the cooperative associations governing water in the Ruhr

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<sup>19</sup> As noted previously, Kneese (1964) is an early application of the Coase theorem. How this theorem came into the environmental economics literature is a matter of some speculation (Medema 2014a,b, 2020b). Given Kneese's early background in industrial organization, and the fact that Kneese (1962) discussed the idea of the basin-wide firm without mentioning the negotiating result, a likely explanation is that Kneese was already thinking along these lines by working through the logic of "The Nature of the Firm"—not the "Problem of Social Cost." Kneese's citation to Stigler and to an edition of Coase's paper reproduced in the 1952 Stigler-Boulding graduate reader supports this theory. Medema 2020b suggests that Jerome Milliman, who was visiting RFF around this time, may have pointed Kneese to the "Problem of Social Cost." If so, it is plausible that it fit comfortably into Kneese's existing thoughts on the subject.

Valley, which used pollution prices among other tools (1964, Ch. 7; Kneese and Bower 1968, Ch. 13).

Second, just as it showed care about institutional details, Kneese's work embedded careful attention to the physical details of the production process in an economic model, in contrast to most neoclassical models that treat production at a high level of abstraction.<sup>20</sup> These details included how energy and materials are passed through the production process to jointly produce marketed outputs and wastes, a line of work he later developed in his work on residuals and materials balance (Ayres and Kneese 1969, Kneese et al. 1970). Too, they included attention to physical place, including the location of economic activity and waste disposal, the delivery of services, and the feedback of wastes on water quality.

Finally, by modeling pollution through the lens of the basin-wide firm, Kneese combined—or perhaps conflated—Pigou's second category of external effects (the one most similar to today's "externalities" and which Pigou illustrated by e.g. chimney smoke) with his third (economies and diseconomies among firms). While Kneese certainly understood the importance of non-rivalry and indivisibility, within the internal logic of the basin-wide firm, upstream water development does not so much affect the public good of individual recreational use of water, as it affects the productivity of the recreation *industry*. It affects the supposed downstream firm selling recreation services (tickets to a private beach). Accordingly, the model of the basin-wide firm allowed Kneese to address pollution questions using the same benefit-cost framework that resource economists had constructed to address questions about resource *development*, questions of economies of scale and scope that were inherent to large-scale water projects. These were the questions that the first generation of environmental economists had been trained to address earlier in their careers (Banzhaf 2009, 2010a, 2019). As discussed above, they were also Kneese's point of entry into work on water resources.

#### **4. Pollution Permits: Thomas Crocker and John Dales**

In the Pollution Pricing family tree, the first cousin to effluent charges is the tradable permit approach, now often called cap-and-trade, under which the right to pollute a fixed quantity can be

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<sup>20</sup> On this point, see RFF (2001 quoting K. Smith) and Nishibayashi (2019). Nishibayashi interprets Kneese's work as following a two-step approach that begins with engineering-economic studies followed by institutional studies.



traded in the market. Whereas effluent charges or pollution taxes set a price on pollution, allowing the market to determine the quantity demanded at that price, tradable permits set an upper bound on the quantity of pollution, allowing the market to determine the price at that quantity supplied. Shortly after Kneese began writing on effluent fees, two economists introduced the idea of such pollution markets, Thomas Crocker and John Dales. Of the two, Crocker eventually had a longer and more active career in environmental economics, yet Dales's work on pollution prices was more immediately influential, with Crocker's early contributions largely recognized in retrospect as tradable pollution permits entered mainstream policy discussions.

Thomas Crocker (b. 1937) received his PhD in agricultural economics from the University of Missouri in 1967, working predominantly with Mason Gaffney, whom he followed to the University of Wisconsin-Milwaukee, where he completed his dissertation and other early work on pollution pricing before eventually landing at the University of Wyoming, where he spent most of his career. (See Crocker 2011 for autobiographical details.)

John Dales (1920-2007) was a natural resource economist who spent most of his career at the University of Toronto. He received his dissertation from Harvard in 1953, working with Walter Isard, a leading economist in regional studies.<sup>21</sup> Like other economists of the period who began to work on environmental issues, much of Dales's early work focused on water resources *development*, with a strong historical-institutionalist flavor. A sampler of his published titles gives a taste, starting with his dissertation, *The Hydro Electric Industry in Quebec, 1898-1940* (1953) and such other publications as "Fuel, Power, and Industrial Development in Central Canada" (1953), *The Protective Tariff in Canada's Development* (1966), and a comment on "Primary Products and Economic Growth" (1967).

While on a sabbatical leave in the late 1960s, Dales turned to the economics of pollution problems, publishing his thoughts in *Pollution, Property and Prices* (1968a), by far his best-known work. The book, which he describes as an "economico-legal" proposal for dealing with pollution (p. vi), introduces the benefit-cost logic of pollution abatement, but also limits it to a logical organizing principle. Setting benefit-cost analysis up as a strawman, Dales knocks it for having a host of measurement problems that prevent it from being a reliable empirical guide in practice (pp.

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<sup>21</sup> Interestingly, this is the same year, and same advisor, as John Krutilla.

34-8, 44-50). In language that would be echoed in Demsetz's "nirvana fallacy" (1969), Dales argued that benefit-cost logic had the potential to be deceptively simple, seemingly "solving" difficult social problems when, in fact, "they were solved because we took great pains to adopt assumptions that made them solvable" (p. 36). Unlike the blackboard, realistic solutions to real-world problems, he said, required humility and recognition that ignorance is endemic to policy making (39-40).

Rather than focus on the intractable question of what is to be done, then, Dales turned to the economico-legal question of *how* it was to be done. His answer: Devise a system of property rights and other incentives that would let the market solve the benefit-cost problems. Even here, he said, there is no perfect solution, because private agents in the market, free riding, still will not fully reflect social values in their decisions, even as public agencies do not know the true values. Dales's proposed compromise was that a Water [or Air] Control Board set up a market by creating a certain number of pollution Rights, each giving the bearer the right to discharge one ton of wastes.<sup>22</sup> If the number of Rights is binding on pollution emitters, they will have scarcity value (p. 93). This approach would have the advantage, he argued, of (i) having lower administrative and policing costs than traditional regulations; (ii) of providing more certainty over the level of environmental quality than pollution charges, which would require a good deal of trial-and-error to find the price that induced the desired quality (p. 82); and (iii) of still achieving that level of environmental quality at the lowest cost possible.

As with Dales, Crocker introduced a system of tradable pollution rights. But whereas Dales proposed what today would be called a system of emissions rights, Crocker proposed what today would be called ambient rights. The former lumps a group of polluters together and allows them to trade emissions 1:1, regardless of where those emissions end up, the latter lumps together all polluters who affect a specific region and allows them to trade at a ratio commensurate with their effect on that region. Each source would have to buy permits in separate markets for each region it affects, with relative prices between sources proportionate to their relative effects in each region. Thus, if Source 1 is further upwind from Region A than Source 2, it might need to buy fewer Region-A permits for each ton of its emissions than does Source 2. Similarly, he envisioned inter-

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<sup>22</sup> Note Dales's use of big-R "Rights," in contrast to the "tradable permits" that later developed in US policy. Dales had envisioned a stronger property right than the privileges granted by permits.

temporal variation in prices (with permits earmarked to specific seasons of the year or times of day). Thus, Crocker envisioned a much more elaborate system of rights than did Dales.

Again as with Dales, Crocker conceded there was no perfect system, so the real question was the relative merits of a given institutional design. But tradable pollution rights, he felt, have the compelling advantage of leveraging the information-signaling power of the market price system while sidestepping "all the guesswork involved in attempting to estimate individual estimator and receptor preference functions" (1966 p. 81). He also felt it is much more practical than effluent charges or subsidies. "Although the theoretical results of varying taxes and/or subsidies and of observing actual market-determined prices may be similar," he argued,

Unless the control authority is willing to vary its taxes and subsidies over rather wide ranges for each receptor and emitter site and for each time period being considered, it will be posed with the technically impossible problem of estimating ranges of preference functions for which it has no information." (p. 82).

As Crocker (2011) recalls it, his ideas initially were developed in reaction to Kneese's proposals, and later he would take Kneese on more directly (Crocker 1968, 1972). Crocker took it for granted that achieving an ambient standard was the most important goal of pollution pricing, so he felt pollution charges were too indirect a method, requiring knowledge about the price-abatement relationship or excessive experimentation to learn it. Curiously, he did not seem to feel his own system had similar difficulties, though it required information about the transmission of pollution from each source to each receptor to set the correct trading ratios.

### *Pollution Trading in Context*

How shall we situate pollution trading in the context of the extant economics literature on externalities and property rights? Dales noted his intellectual debts to Coase's "Problem of Social Cost" as well as Charles Reich's "The New Property," and also to Scott Gordon's (1954) work on "The Economics of a Common-Property Resource" (pp. 110-1). He also cited Kneese (1964) as an important point of reference. For his part, Crocker was sparing in his citations in his early work, but later did discuss his proposals in relation to Kneese's and Gordon's model of the commons (1967, 1968, 1972).

What is clear from the outset is that there is absolutely no reference in either Crocker's work or Dales's to Pigou. Of course, they contrasted their ideas to Kneese's effluent charges, but

Kneese's work, as I've argued, is not obviously Pigouvian either. If anything, its institutional approach bore some affinity to Coase's.

That brings us to the Coasean origins of marketable pollution rights, if any. Many standard summaries of environmental economics do draw the connection (e.g. Tietenberg 2010, Stavins 2011). On the other hand, Berta and Bertrand (2014) and Medema (2014a) have taken the opposite view, arguing that cap-and-trade is closer in spirit to Arrow's (1969) model of complete competitive markets than to Coase's vision of bilateral bargaining. While Dales (1968) acknowledges "owing much" to "The Problem of Social Cost," it appears to be more for its general connection between law and economics.

As I've argued elsewhere, personally I do believe there is enough affinity between Coasean ideas and pollution trading to warrant making the association, if for no other reason than that Coase himself was proud to accept credit for the idea.<sup>23</sup> Although one could argue that Coase's vision was more about bilateral bargaining, in fact, in the US, actual pollution trading policies did evolve out of experience with bilateral trades, in particular EPA's "bubble" and "offset" programs.<sup>24</sup> More generally, pollution trading can fairly be described as Coasean insofar as it (i) clarifies property rights to environmental resources like the atmosphere and introduces enforcement mechanisms for violations of those rights; (ii) reduces transactions costs by commodifying pollution, with clear units of measurement and centralized market platforms; and (iii) allows trading. Such trading becomes more Coasean in character the more salient are trades between greens and browns that endogenize the final quantity of pollution released—that is, when the "cap" in "cap-and-trade" is an upper bound on pollution and environmentalists can retire pollution rights—in contrast to fixed caps allocated only among polluters. In a Coasean worldview, such green-brown trades are linked

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<sup>23</sup> For discussion of the points summarized here, see Banzhaf (2010b, 2020) and Banzhaf, Fitzgerald, and Schnier (2013).

<sup>24</sup> In the US, the 1970 Clean Air Act prohibited new sources of emissions in counties designated as being in "non-attainment" with ambient air quality standards, while also regulating emissions of existing sources more stringently. To lighten the costs of these regulations, in the mid-1970s the US EPA introduced an offset program to allow new sources in non-attainment areas if they could find an existing source to reduce their emissions by 1.2 tons for each ton of new emissions. Later, in 1979, the program was extended to include trades among existing sources. These programs had narrow geographic scopes, involved bilateral trades with no central market, and had to be individually approved by EPA. But it is widely believed that experience with these programs created a level of comfort with pollution trading that paved the way for later cap-and-trade programs such as the 1990 acid rain program. See Tietenberg (2006) for discussion.

to the idea of reciprocal harm associated with the opportunity costs of using the atmosphere for one use versus another (e.g. deposition of wastes vs. maintenance of health, property and, today we might add, ecosystem services).

Such reciprocal costs were a linchpin in Crocker's presentation of pollution trading. Even if, he said, a marginal decrease in pollution increased net benefits, yet still,

We are no more justified in making the would-be emitter endure all the costs of "pure" air while the would-be receptor receives all the benefits than we are in burdening the receptor with all the costs of "dirty air while the emitter collects all the benefits. (1966 pp. 62-3)

In this, Crocker disagreed with Kneese, who held up the polluter-pays principle of effluent charges as one of its virtues. Elaborating, Crocker added that

One would therefore expect the market to allocate the air's two value dimensions according to the criteria of economic efficiency. Receptors and emitters could be expected to exchange rights to the life- and property-supporting dimensions and the waste-disposal dimension until . . . the difference between total cost savings to emitters and total damage costs to receptors was maximized.

However, so far society has generally been unable to define property rights to air..." (1966 p. 65)

Such trades have signaling potential, he said, to reveal the economic value of air resources. However, such green-brown trades also face free-rider problems on the green side of the market (pp. 66, 84), which justifies public intervention. So, in the end, they were more interesting to Crocker as a theoretical possibility than a likely reality.

Dales too cracked open the door to such trades between the green and brown sides of the market. "Conservation groups," he said, "might well want to buy up some rights merely in order to prevent their being used. In this way at least part of the guerilla warfare between conservationists and polluters could be transferred into a civilized 'war with dollars'" (1968a pp. 95-6). Elsewhere, though, he minimized this possibility, characterizing his proposal as nothing more than an administrative tool. In contrast to "true" or "natural" markets, which involve "two-way communication between sources of supply and demand," he described his artificial market as providing only one-way communication, transmitting the government's decisions about the cap on pollution to the users but without the reverse feedback, so that the resulting scarcity value has no effect on the quantity of pollution supplied, nor does the value of the competing amenity use (1968b pp. 803-

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Soon, additional work extending Dales's model would place it more in the style of work of the Cowles Commission. Montgomery (1972), picking up on Dales's (1968b) emphasis on the artificiality of the markets, essentially crossed Dales's model with that of Arrow (1969), embedding it in an Arrow-Debreu model of competitive equilibrium.<sup>25</sup> Weitzman (1974a) reimagined it as an application of socialist command-and-control over quantities, interpreted as dual to Lange-Lerner price controls.<sup>26</sup> Such interpretations tend to minimize the potential for green-brown trades, emphasizing allocation among polluters of a fixed aggregate quantity.

At most, then, Coase was but one touchpoint in the intellectual network in which pollution trading operated, as it was for Kneese's proposals for effluent charges. And Pigou was hardly mentioned. As I discuss in the next section, if we are hunting for the intellectual history of pollution pricing, the recurring references to Gordon's (1954) work on common property are a more promising lead to follow.

## **5. Alternative Sources for Pollution Pricing**

As influential as Pigou and Coase obviously have been, I suggest it is simply a categorical mistake to interpret the history of pollution pricing, at least as it developed in the US, through the lens of old rivalries between Cambridge and LSE. In fact, the pioneers of American environmental economics were trained in agricultural and natural resource economics or regional economics, were steeped in applied work, and had their own American literature and history of applied practices on which to draw (Banzhaf 2009, 2010, 2019).

The connection—or lack thereof—to Pigou can perhaps best be elucidated by revisiting his three categories of situations where there is, in his view, a divergence between private and social benefits and costs. The first, recall, includes situations where productive investments might potentially be made by people who do not own the instrument of production being maintained or enhanced, such as tenant farmers. The second involves situations where one person, when rendering some compensated service to another, incidentally also renders services or disservices to third

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<sup>25</sup> See Berta (2017) and Berta and Bertrand (2014) for discussion of this approach to modeling externalities.

<sup>26</sup> Even here, there connection to property rights remains: Weitzman, interestingly, at the time was also working on common property and enclosure movements, albeit from a more heterodox perspective (Weitzman 1974b, Cohen and Weitzman 1975).

parties. The third comprises situations where there are increasing or decreasing returns at the industry level. Though with antecedents in Mill and Sidgwick, Pigou's second grouping is the one most original to and uniquely associated with him. Additionally, it is the one closest to today's concept of "externalities," and which had gone dormant in the literature from the 1930s to '60s.

But if we are trying to understand the historical context of pollution pricing circa 1960, I suggest it is the first and third groupings—*not* the second—that are most relevant. Being less unique to Pigou, these issues could then more likely have been associated with other, non-Pigouvian traditions.

Let's consider first the notion of external economies (or diseconomies) from one firm to another within the industry, or from one industry to another, with expansion by one firm changing the supply price of other firms (Pigou's third grouping). These kinds of effects were historically important for environmental economics because its intellectual roots lie as much in the study of natural resources as public goods and externalities. And, at least in the US, studying natural resources meant studying their *development*. Development of resources was, arguably, engrained in the American worldview well into the mid 20<sup>th</sup> Century. In his Frontier Thesis (1893), Frederick Jackson Turner had famously argued that America's civil and social development were dependent on its resource development: As Americans moved west, taming the frontier made them ever more self-reliant, while as settlements grew in its wake they became more civilized as well. Here is a story of external economies writ large: The development of resources spilled over to all civilizing and democratizing forces. Whatever the merits of Turner's thesis, it was quite influential. Consequently, the closing of the frontier in the late 19<sup>th</sup> century prompted renewed efforts to develop existing resources.

In the American west, developing water resources was a paramount concern. West of the 100<sup>th</sup> meridian, farming required irrigation, but as noted by Teele (1904, 1926) even early irrigation ditches required cooperative construction and management, as a ditch scaled to serve only a single farm would lose all its water to evaporation. Thus, economies of scale at the industry level were present. As recently argued by Leonard and Libecap (2019), the evolution of water rights in the American West from riparian rights to prior appropriation was one organic response to this problem. Later, larger-scale development of ever larger regions, further from water sources, seemingly justified federal support for massive water projects.

This push for development might appear to conflict with the growing conservation movement led by Gifford Pinchot (1865-1946) and others, but the conservation movement, perhaps ironically, emphasized developing resources as much as conserving them.<sup>27</sup> From Pinchot's perspective, development and conservation were two prongs in the progressive attack on waste. As he wrote in *The Fight for Conservation* (1910):

The first principle of conservation is development, the use of the natural resources now existing on this continent for the benefit of the people who live here now. There may be just as much waste in neglecting the development and use of certain natural resources as there is in their destruction. ....

Conservation stands emphatically for the development and use of water-power now, without delay. It stands for the immediate construction of navigable waterways under a broad and comprehensive plan as assistants to the railroads. More coal and more iron are required to move a ton of freight by rail than by water, three to one. In every case and in every direction the conservation movement has development for its first principle, and at the very beginning of its work. The development of our natural resources and the fullest use of them for the present generation is the first duty of this generation. ....

In the second place conservation stands for the prevention of waste. There has come gradually in this country an understanding that waste is not a good thing and that the attack on waste is an industrial necessity. I recall very well indeed how, in the early days of forest fires, they were considered simply and solely as acts of God, against which any opposition was hopeless and any attempt to control them not merely hopeless but childish. It was assumed that they came in the natural order of things, as inevitably as the seasons or the rising and setting of the sun. Today we understand that forest fires are wholly within the control of men. So we are coming in like manner to understand that the prevention of waste in all other directions is a simple matter of good business. The first duty of the human race is to control the earth it lives upon. (1910 pp. 43-5)

Thus, Pigou was only half right when he stated that "the whole movement for 'conservation' in the United States is based on" the conviction that "the State should protect the interests of the future *in some degree* against the effects of our irrational discounting and of our preference for ourselves over our descendants" (1932 p. 29). The other half of the story is that the state should develop resources immediately so they are not "wasted" by remaining unused.

Such thinking was quite influential. At a famous Governors' conference on conservation

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<sup>27</sup> See Hays (1959). Banzhaf (2019) discusses the importance of this aspect of the conservation movement in the history of environmental economic thought.



organized by Pinchot, President Theodore Roosevelt remarked in his opening address that:

Every step of the progress of mankind is marked by the discovery and use of natural resources previously unused. Without such progressive knowledge and utilization of natural resources population could not grow, nor industries multiply, nor the hidden wealth of the earth be developed for the benefit of mankind.

These concerns continued into the middle of the century, when they began to occupy the interest of the economists who would shape environmental economics in the coming decades. Consider just the titles of three key works in benefit-cost published in 1958 alone:

- *Multiple Purpose River Development*, by John V. Krutilla and Otto Eckstein;
- *Water Resources Development: The Economics of Project Evaluation*, by Otto Eckstein; and
- *Efficiency in Government through Systems Analysis with Emphasis on Water Resource Development*, by Roland McKean.

Around the same time, Kneese published "Normative Problems in the Evaluation of Water-Resources Development Projects" (1960), discussed above. Before they were calling attention to the deleterious effects of development on environmental amenities, Kneese and Krutilla were focused more on the beneficial spillovers of development, mentioning environmental externalities only in passing. Instead, they identified the crucial issue creating departures from competitive conditions as large external economies from indivisibilities and jointness in production technologies and from interdependence in of the production functions of independent producers (Krutilla and Eckstein 1958 pp. 42-77). Jointness meant that most water projects were multi-purpose, so could be thought of as direct inputs into several industries simultaneously, with no one industry (let alone firm) having the full incentive to invest in them. Interdependences implied further indirect effects from one firm to another. For example, both Krutilla and Eckstein (1958 pp. 56-7) and Kneese (1960 pp. 311-12) mention the possibility that irrigating some farms from surface water would recharge the aquifers used by other farmers. Similarly, upstream storage presents external economies to downstream hydroelectric power. At a larger scale, development of sparsely populated areas can enhance productivity by increasing the extent of the market and so extending the division of

labor.<sup>28</sup>

Even when their focus turned from natural resource scarcity to scarcity of environmental amenities, this pattern of thought continued to guide economists' thinking. For example, as discussed above, Kneese often thought in terms of the *joint* effects of firms and industries on pollution levels within a collectively shared water resource, which in turn affects downstream industries like recreation (Kneese 1964, Kneese and Bower 1968), an extension of inter-industry external economies that fit Coase's ideas as well as Pigou's. Earlier, questions about how to measure the monetary value of such outdoor recreation—arguably the first exercises in pricing the environment—first arose from thinking about ancillary benefits of building reservoirs in order to justify more development projects (Banzhaf 2010, 2018). Finally, Krutilla (1967) introduced the possibility of external economies from learning-by-doing in outdoor recreation, as investments in environmental amenities induced participation that would then beget more participation, increasing the value of the initial investment. Thus, early work in environmental economics often was framed in terms of industry-wide spillovers and economies of scale.

Equally important are the issues that might be placed into Pigou's first grouping, land tenancy. Here especially, American economists had their own traditions to draw on. To see this, one need look no further than Pigou's own text, where at points he relies on Henry Taylor's discussion of certain contractual arrangements that can help overcome land tenancy problems (Taylor 1919). Taylor, a student of Richard Ely's, was one of the central figures in the creation of American agricultural economics (see Banzhaf 2006).

This grouping is as close as Pigou came in the *Economics of Welfare* to discussing property rights arrangements for the use of natural resources. Whereas in the other two groupings he thought in terms of the *effects* of particular *actions*, here Pigou thought in terms of investment in or depreciation of a natural resource (land) being used by multiple agents (the tenant now, but eventually the owner when it reverts back to him or another tenant who takes up the lease). Thus, though Pigou primarily discussed the incentives of a tenant farmer, the logic applies to other situations where individual have an incentive to deplete a resource held in common.

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<sup>28</sup> As discussed in Porter (1995) and Banzhaf (2009), quantifying such secondary benefits was hotly contested in applied benefit cost analysis. The Federal Inter-Agency River Basin Committee's so-called "green book" (1950) downplayed their importance.

That common property resources are germane to environmental problems is almost too obvious to spell out, but three historical touchstones—all making use of metaphors to agricultural property—highlight its importance as a recurring theme in North American conservation and environmental thought. In 1968, near the peak of the environmental movement, Garrett Hardin's "Tragedy of the Commons" invited readers to "picture a pasture open to all. It is to be expected that each herdsman will try to keep as many cattle as possible on the commons" (p. 1244). The result is ruin for each herdsman, as overgrazing destroys the grass. In the same way, Hardin said, the earth and its ecosystem are a common resource supporting all humanity, a commons being depleted. Whatever the merits of Hardin's arguments, it struck a popular chord, with discussions of common property ballooning in the environmental literature soon after.

Second, over a decade earlier, Scott Gordon's "Economic Theory of a Common Property Resource: The Fishery" (1954) also had drawn attention to common property problems, in his context resulting in overfishing. But Gordon too made the connection to common tenure in land, with a discursive discussion of hunting and trapping as well as agriculture, and the endogenous formation of alternative forms of tenure when resources become scarcer (pp. 134-5).<sup>29</sup>

Finally, even earlier, at the 1908 Governors' conference, President Theodore Roosevelt drew a parallel between the nation's stewardship of natural resources and a farmer's stewardship of the land. After discussing the excessively rapid depletion of mineral resources, Roosevelt broached the stewardship of renewable resources, like the soil, forests, and waterways. The problem, he said, could be understood by analogy to a farmer's stewardship of the soil. "Every one knows that a really good farmer leaves his farm more valuable at the end of his life than it was when he first took hold of it. So with the waterways. So with the forests." But stewardship of the land is grounded in the incentives of property rights. "We should exercise foresight now," he said,

as the ordinarily prudent man exercises foresight in conserving and wisely using the property which contains the assurance of well-being for himself and his children. We want to see a man own his farm rather than rent it, because we want to see it an object to him to transfer it in better order to his children. We want to see him exercise forethought for the next generation. We need to exercise it in some fashion ourselves as a nation for the next generation.

In this way, care of resources can be understood by analogy to questions of land tenure.

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<sup>29</sup> See also Scott (1955), who also considered the appropriate spatial scale of property rights.

An alternative reading of the 1960s literature on pollution pricing suggests they were thinking along just these lines. Kneese, recall, had segued from a discussion of the farm with Plots A and B to the basin-wide water firm. Certainly, like Pigou, he considered situations where an exchange between two parties affects a third party. But, reasoning with categories of natural resources which have alternative uses, Kneese considered how such affects are mediated through misaligned incentives to allow a resource to depreciate: "*Failure of municipal and industrial waste dischargers to consider that subsequent water uses may be made more expensive or foreclosed entirely by the discharge is perhaps the basic element of the pollution problem*" (p. 42, emphasis in original, underline added). In other words, polluters depreciate a resource that has alternative uses downstream, such as fishing. Downstream users of the water, here, subsequent in time and space to the upstream user, play the role of subsequent users of farmland after the tenant. If Kneese was thinking in these terms, it is not surprising that his writing transitions seamlessly between sounding very "Pigouvian" on one page and "Coasean" on the next (e.g. 1964, pp. 36-52).

Explaining his proposals for effluent charges to the US Congress, Kneese (1969) framed it in the property rights context. "I think we must devise ways of reflecting the costs of using resources that are the common property of everyone, like our watercourses," he said. "Because our property institutions cannot adequately be applied to resources like watercourses, and for that matter the air and space, they are in fact unpriced and treated as free goods, even though they are in fact resources of great and increasing value in the contemporary world. ...[T]his unfortunate situation cannot be remedied unless we move toward the implementation of publicly administered prices for waste discharge to watercourses and for the use of other common property resources" (p. 347).

Crocker and Dales also reasoned from this mis-aligned incentives of common property, with Gordon (1954) being one of the few references provided by either (Crocker 1967, 1968, Dales 1968a,b). Both authors drew the connection between pollution problems and the problem of open access to the commons (Dales 1968a 61-5, Crocker 1967, 1968). Dales emphasized that, because air and water are fluids that fail to respect boundaries, it seems inevitable that they will be held in common. Crocker made a similar point, adding that whereas with land and most other resources, man can modify its characteristics to suit his needs, with air we are subject to its whims (1966 p. 63).

Crocker additionally stressed the distinction between "air" and "air space," the former referring to the gasses that move about in space and time, and the latter the space through which they move. This distinction is interesting because it echoes one Richard Ely—the Godfather of American land and agricultural economics—often made between "land" and "standing space." At the end of his career, Ely and Wehrwein organized their definitive text *Land Economics* (1940) around this distinction to develop their theories of property rights, resource rents, and the depletion of soil fertility and natural resources. For example, like land, they said, water resources too can be distinguished between the space it occupies and the resource itself. Because underground water flows throughout a basin, a single user can deplete the reservoir, particularly problematic in the arid west. Thus, California for example developed the doctrine of "correlative right," which limits users to a reasonable share (see also Ciriacy-Wantrup 1956). Earlier in his graduate career, Crocker had been assisting his advisor on just this issue (Gaffney 1961 p. 30), and he recalls it being an important inspiration for his work on rights to the air (Crocker 2011). Highlighting this connection, Crocker wrote that the current treatment of property rights to air obviously resembles "the problems caused by the old absolute-ownership doctrine of groundwater" (1967 p. 36).

This old doctrine of absolute ownership, Crocker explained, "defines the groundwater user's rights in terms of reservoir space, but fails to define his rights relative to the rights of other groundwater users in the water that percolates through that space." Even if users had a *de jure* right, they would have no economical means by which to defend them (1967 p. 36). For air as with groundwater, "the result is that the owner of the space uses the resource within the space until such time as for him and him alone the present value of its marginal value product is zero" (1966 pp. 82-3).

Crocker and Dales both suggested that, although historically it was appropriate to treat air or water as a "free good," the demands on their use were now too high to do so. The problem with the commons, Crocker summed up, was, quoting Bator (1968) and Gordan (1954), that the "'divorce of scarcity from effective ownership' brings about a situation in which 'the conservative dictum that everybody's property is nobody's property' appears to be fulfilled" (1968 pp. 247-8).

On this reading, if the Pigouvian framework was later grafted onto the rootstock of an already flourishing school of environmental economics, the roots of that school were already well

grounded in an American tradition of applied agricultural economics and natural resource economics.

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