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All in the same boat: externalities, interdependence and the commons of Venice lagoon

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Abstract

Venice Lagoon has a complex relationship with the many economic activities it hosts: tourism, oil refineries, a logistics hub, agriculture, households, and fisheries heavily affect the condition of the lagoon. At the same time, they all strongly rely on the environmental services it provides. Against a situation where each economic sector is simultaneously cause and victim of such "disturbances", this papers reviews the contribution of economic theory to envisioning a governance structure for Venice Lagoon capable of acknowledging the mutual interdependencies between the activities it hosts. The paper presents and critically reflects upon two competing perspectives: externalities and interdependence. It then introduces the specifics of the Venice Lagoon case, and reflects on the prescriptions derived by both concepts. Finally, it evaluates the core traits of the current regulatory framework in the light of the theoretical discussion.

Keywords: Externality, Interdependence, Venice lagoon, Economic theory, Governance

Introduction

The Lagoon surrounding Venice, Italy, has a complex relationship with the several economic activities it hosts: tourism, oil refineries, a logistics hub of country-wide importance, agriculture, households, and fisheries. All these activities heavily affect the condition of the lagoon, while, at the same time, they strongly rely on the environmental services it provides. Conversely, the lagoon itself is a product of human intervention and could hardly be preserved in its present form without continuous maintenance and re-shaping activities. Such activities are costly and can only be sustained with resources originating from the economic activities that take place within the lagoon's boundaries.

Venice Lagoon presents a situation where economic activities are simultaneously cause and victim of the lagoon's environmental problems. The question whether they are desirable in their present form or should rather be curbed is most certainly not a trivial one, going well beyond the possibilities of a single paper. The present work contributes to that question by reviewing concepts from economic theory, helping to frame the situation at hand. Acknowledging the heterogeneity within the economic scholarship, the paper addresses contributions from both neoclassical and ecological economics, critically reviewing prescriptions from the externality and the interdependence literatures.

Doing so is certainly worthwhile on its own account. It is, however, particularly important in light of the European Water Framework Directive and its emphasis on economic analysis. An overarching piece of legislation with key implications for the governance of Venice Lagoon, the Directive makes provisions concerning subsidization, cost recovery, disproportionate costs, and the trade-off between environmental objectives and the public interest. It is thus worthwhile to draw an economic perspective on Venice Lagoon, and explore its implications for the present regulatory framework, and the constraining and enabling economic activities therein.

With that goal in mind, the paper is structured as follows. It first summarizes tenets from economic theory relevant to Venice Lagoon, focusing on the concepts of externality and interdependence. Subsequently, it spells out the specificities of the Venice Lagoon case and provides an analytical framework. It then reviews current arrangements in light of this analytical framework and contrasts it with the prescriptions from the externality and interdependence literature. The final section provides some conclusions and recommendations.

Insights from standard economic theory: externalities

Externalities represent a widely debated topic within environmental and resource economics: we refer here to the body of literature concerned with the problem of social costs (Pigou 1932; Coase 1960; Buchanan 1969a). In a nutshell, whenever transactions between private actors generate costs for other actors not involved in said transaction "the invisible hand doesn't work" (Kahn 2004). Regulation is required as markets alone generate allocative inefficiency.

In order to understand the above, some definitions are due. Standard economic theory assumes economic actors to be "rational" and engage in activities only to the extent these have greater expected benefits than costs. For firms, costs and benefits constitute monetary expenditures and revenues, behavior being driven by profit maximization. The behavior of individuals is instead driven by the maximization of utility – the sum total of the pleasure (benefit) and pain (cost) connected with the individual enjoyment of particular goods and services.

Externalities arise when individuals and/or firms engage in activities which entail for them greater benefits than costs, but also create costs to other actors. To the extent the sum of *both* costs (those borne by transacting actors and those borne by others) is greater than the benefits, the activity is privately rational, but socially irrational. The core of the debate concerns how to redress this situation, so that privately rational choices are socially rational as well. Two major schools of thought exist on this question: the Pigouvian and the Coasean. While the first proposes a targeted use of taxation, the second is centered on the ability of the actors to bargain a mutually satisfactory outcome.

Common to both schools is the reference to Pareto efficiency as a choice criterion, together with the view of a regulator as a well-meaning actor, whose aim is to maximize the overall welfare of society. Under these premises, the task for the regulator is one of dealing with externalities by devising arrangements in such a way that those made worse off by such arrangements are less so than those made better off by them (potential Pareto improvement or Kaldor-Hicks efficiency).

In other words, whatever policy or collective choice addressing external costs is bound to be profitable for some and unprofitable for others. If those that gain from it gain more than those who lose from it in aggregated terms, there is a net profit for "society" as envisioned by Pareto – a statement which is certainly controversial enough, but needs to be endorsed in order to understand what economists mean when they refer to (Pareto) efficiency.

Against this background, the entry point of the Pigouvian tradition is that by taxing the externality generating transaction at a level that equals the external costs it produces, private and social costs are equated: if individuals act by matching private benefits with private costs, and private costs match social costs, individuals will act in welfare-maximizing ways, achieving Pareto-efficient outcomes. This argument was made in pre-marginalist terms, in an environment, therefore, characterized by interpersonal commensurability of utility: external costs are seen as a quantification of the loss experienced by third parties, while the tax represents a form of compensation. The same argument has been shown to hold in a marginalist environment too, where only (relative) prices can be referred to as an expression of utility: efficient prices must include external costs, regardless of any compensation taking place (Baumol 1972, Hartmann 1982).

The claimed efficiency of a Pigouvian Tax has a key implication for policy: if the tax is "right", there is no need to prescribe a desirable level for the externality at stake. By equating marginal costs and benefits, the taxed activity "automatically" achieves a desirable level of the externality at stake. In their basic understanding, Pigouvian approaches describe a world without environmental standards, and where the polluter-pays-principle is the only control on the level of externalities, ensuring they are neither too high (imposing unnecessary limits on economic activities) nor too low (creating costs for society that are higher than the benefits they allow for). Obviously, the above holds only under a very restrictive assumptions about economic activities and the costs and benefits they entail. While (Insights from Ecological Economics: Interdependence section) addresses such assumptions more in detail, it would be too early to dismiss Pigouvian approaches just yet.

An important and complementary take on Pigouvian approaches is one were the level of an externality generating activity is "controlled" through taxation: by increasing or decreasing the tax, a regulator can "efficiently" achieve a desired level of abatement, and hence of external costs (Baumol and Oates, 1988). The difference is subtle, but important: instead of letting markets determine autonomously the "optimal" level of environmental quality, the regulator limits itself to imposing a tax, raising it up to the point where the taxed externality is curbed to a desired level. This perspective will be termed Quasi-Pigouvian. Other than before, whether the thus achieved level of the externality is efficient or not depends on how the regulator has set it. Assuming "rational" actors, the use of the tax instruments merely guarantees that polluting activities will not take place if they are worth less than the tax.

The Coasean tradition, instead, focuses on the reciprocal nature of externalities (Coase 1960; see also Wirl 1992). By doing so, it slightly changes the problem by acknowledging that it takes two sides to make an externality: a "polluter" and a "victim". Since abatement is not necessarily cheaper on the polluter side than it is on the victim side, any approach aiming at Pareto efficiency should allow for such comparison of abatement efforts. A Pigouvian tax neglects to do so as it focuses solely on the costs victims incur because of the polluter.

Following this logic, victims are seen as having an incentive to improve their situation through side payments to the "polluter". Interestingly, this reasoning also holds for the symmetrical case where victims have property rights and the polluter pays them to protect themselves rather than reducing pollution on the production side. Whether it's costlier to reduce pollution on the victim vs. polluter side, is ultimately a technological question. Coase's claim is that, if transaction costs are negligible, a clear assignment of property rights is all it takes to reach Paretian efficiency through bargaining between the polluter and the victim, regardless whether they lie in either hand – a tax is not necessary. This is the essence of the (invariance claim of the) Coase Theorem.

The theorem has clear limitations. Next to the consideration for transaction costs, the line of reasoning proposed by Coase applies only to nuisances which can be clearly demarcated, attributed to specific activities, unambiguously priced and effectively abated under certainty, with perfect knowledge and under competitive prices. Furthermore, bargains between victims and polluter are assumed not to affect those competitive prices providing the basis for the monetary valuation of the respective abatement options. Such limitations have been dealt with by Coase himself and have led to different readings (Baumol 1972; Bromley 1989; Demsetz 1996; Medema 1998; Paavola 2007; Usher 1998; Vatn and Bromley, 1997). For our purposes, the demarcation and attribution dimensions will pose the strongest challenge, next to the absence of effects upon prices. The message for policy is nonetheless that government intervention focusing on the polluter might overlook less costly abatement possibilities on the side of the victims, encroaching on their incentives to protect themselves, and stimulating rent-seeking behavior (Buchanan 1969a; Wirl 1992).

In Coase's view, a correct economic analysis shall consider alternative arrangements and evaluate them in terms of their respective contribution to the "total social product" (Coase 1960, pg. 34), taking into account the administrative costs connected with each alternative arrangement and with a transition from the status quo to a new arrangement. Considering that positive transaction costs will affect the outcome in different ways according to where property rights are placed, it becomes preferable to make an informed choice on the assignment of property rights and leave the polluter and victim themselves to bargain towards an efficient level of external costs. The extensive literature on tradable permits can be seen as an offspring of this approach. It is worthwhile noting, though, that the "cap & trade" option represents solely a quasi-Coasean strategy: trading the available number of permits is meant to provide efficiency in the allocation of the abatement efforts among the polluters, while the overall level of abatement (and therefore the polluter-victim allocation) is normatively imposed through the "cap" and as such does not necessarily represent an efficient level of abatement.

In the light of the two different approaches, the Pigouvian and the Coasean one, the question becomes one of identifying the superior strategy. If the normative basis is that of Paretian efficiency, a judgement in favor of either one is bound to vary with the specifics of the externality at play. Externalities can indeed differ in a broad range of characteristics (Mishan 1971): a brief review of the literature has identified, without any claim of exhaustiveness, several distinctions, such as production vs. consumption externalities (Henderson 1977; Kohn 1993; Terrebonne 1995 for the first; Kohn 1977; Berliant et al. 2002; and Norgaard and Liu, 2007for the latter), standard, reciprocal, correlated and reflexive externalities (Baumol 1972, pp. 310–312; Hartmann 1982; Caplan and Silva, 2004; Kohn 1991 respectively) and externalities under certainty as opposed to those under uncertainty (Graff Zivin and Small, 2003). Moreover, the "public bad" nature of externalities might or might not be taken into account (Baumol 1972; pp. 312–313; Mills 1979; Rubio and Casino, 1999; Xepapadeas 1995), while activities generating the externalities might or might not be marginal within the economy considered and might or might not take place in a competitive environment (Agell and Dillén, 1994; Buchanan 1969b; Barnett 1980; Ebert and von dem Hagen, 1998).

Some examples may clarify the differences at stake in the above. Leaving consumption externalities aside and adjusting standard textbook examples (roaming cattle and crops, factory smoke and laundries) to the Venice context, the standard case for a production externality is one where fishing grounds are lost because of the chemical run-off from the refineries. That externality becomes reciprocal if, by hypothetically moving to different grounds, fishing fleets would clog the lagoon's shipping lanes, affecting the deliveries to the refineries. If the chemical run-off is not only a nuisance for the fisheries, but also for recreational activities in the broader lagoon (e.g. through the loss of bird habitats), the case is one of correlated externalities. Moreover, a fishing fleet being affected by the chemical run-off does not prevent another fleet from being affected by the same run-off – the externality thus representing a public good. If, finally, no other comparable fisheries and/or refineries exist, the externality will affect not only costs, but also determine prices: how much the two economic activities are "worth" depends on the externality.

An in-depth exposition of the way externalities are modeled and analytically treated in the literature goes far beyond the purposes of this paper. It will suffice to point out that the superiority of Pigouvian or Coasean approaches against one another varies with the specific approach chosen to model the situation at hand. Let us therefore focus on those approaches arguably most relevant for the case of Venice Lagoon. In our view, these are those contributions focusing on reciprocal externalities in either production (e.g.: Rucker et al. 2012; Taylor et al. 2014) or consumption (e.g.: Cornes and Sandler, 1985; Dasgupta and Ehrlich, 2013).

The reciprocal nature of such externalities generally forces a game-theoretical approach focusing on the relation between a Nash and a Pareto equilibrium – the former being the outcome actors will achieve based on mutual expectations and no cooperation. In these regards, scholars typically focus their attention on the calculation of the correct Pigouvian tax (e.g.: Cornes and Sandler 1985), even though comparisons of alternative approaches (tax vs. voluntary side-payments vs. command-and-control as in Taylor et al. 2014) and even integrated ones (an environmental tax coupled with voluntary side-payments as in Altemeyer-Bartscher et al. 2011) can be found.

As a result of the game-theoretic treatment, however, contributions are limited by a large number of restrictions aimed at ensuring a mathematical tractability of the specific problems addressed. These range from the completeness and double differentiability of the cost and preference curves involved to limits in the number of agents affected and/or interacting. As a result, it is yet not possible to settle the debate between the Pigouvian and the Coasean approach – neither in general, nor for the specific case of Venice Lagoon. To put it in Partha Dasgupta's words: "Corners have to be cut, and they can be guaranteed to generate controversy" (Dasgupta 2014, pg. 8).

In summary, for a regulator aiming at defining an arrangement so as to maximize the overall level of utility, the approach suggested within the externality literature is either one of a targeted taxation/subsidization or one centered on the assignment of property rights, together with the creation of possibilities and incentives for market exchanges. The only recommendation that can be given in general is one of enabling abatement efforts to be shifted where they are reasonably cheaper. Optimality aside, that is certainly a very powerful heuristic.

Insights from ecological economics: interdependence

Ecological economics represents a wide and diverse transdisciplinary endeavor aimed at exploring the nexus between human economies and the ecosystem. Within it, institutional ecological economics aims at taking stock of the contribution of institutional economics and transaction costs economics while devising governance arrangements that acknowledge actor interdependence, leveraging those contributions from the literature on the commons (Paavola 2008, Paavola and Adger, 2005). Interdependence describes herewith a situation where actors cannot achieve their interests independently of one another; their interests are thus mutually incompatible (Paavola and Adger, 2005). We show in the following that interdependence is deeply rooted in the views ecological economics holds concerning both social and natural systems.

In ecological economics, ecosystems *constitute* the material basis for human economic activities. Natural resources are seen as ecosystem features rather than standalone, isolated objects. The rival character of resources, or the fact that resource units used by one actor are not available for use by other actors, is directly affected by their interdependence. Certainly, not all ecosystem features are rival, but those that are become even more so if ecological links to other resources are introduced: any resource withdrawal by one actor is bound to encroach on the harvest of other users; by the same token, users of rival resources do not only have to deal with other users of the same resource, but also with the users of other resources, connected through ecological links to the resource at stake. Furthermore, ecosystem complexity might cause such ecological links to remain partly or fully unknown at the moment of decision, implying "functional invisibility", or imperfect ecosystem knowledge (Bromley 2007, Vatn 2005).

Concerning the socio-economic system, the most salient assumption is that of intrapersonal incommensurability, accompanied by transaction costs, contingent and socially constructed preferences and multiple rationalities: the limited cognitive capacity of individuals makes them only partially able to consider the entire set of consequences for their actions and to derive net sums of all pros and cons (Simon 1955). Information costs, on their part, impede utility maximization at individual level: preference sets are assumed to be incomplete and change during a choice situation. Multiple rationalities, finally, reflect the acknowledgement of different logics underlying different spheres of human interaction (Vatn 2005).

Preferences are seen as socially and not individually constructed (see Vatn and Bromley, 1994): social interaction becomes a venue where competing logics for action, mutually excluding rationalities (with both their normative and ontological consequences) are contingently and collectively settled. Governance arrangements can only be considered satisfactory if they emerge from venues and processes capable of collectively and legitimately identifying those interests perceived as worth societal protection (Vatn 2005; Paavola 2007; Paavola and Roepke, 2008). Against this background, resource regimes entail the qualitative and quantitative terms according to which a given ecosystem feature can be accessed by users. Interdependence emerges here as the rights (for some) conferred by resource regimes that correspondingly assign duties (for others) not to encroach on the resource users' rights (Samuels 1971, 1989; Bromley 2006).

Devising regimes for the use of interdependent resources becomes hitherto a question of distributing both rights and duties among users in a situation of ecological distribution conflict (Martinez-Alier 2001; Muradian & Martinez-Alier 2001; Paavola 2004). The task of a regulator becomes one of allowing the societal identification of a normative basis for conflict settlement and designing regimes to explicitly reflect that: in contemporary democracies this corresponds to the work of parliaments and courts (Bromley 2004, 2006).

We can identify here a first prescription in the sense of the *explicit* identification of a normative basis for the distributional choices inherent in institutional design. The normative foundation for this prescription is procedural in nature as it connects with quality control on decisions: when facts are uncertain (imperfect ecosystem knowledge) and values are debated (normative and distributional dimension of institutions), an "extended peer review" has been proposed as an adequate strategy for an informed decision-making (Funtowicz and Ravetz, 1993, 1994). Verification through civil society of the adequacy of the normative basis for decision-making can be placed under such perspective (Bromley 2007).

Regardless of its explicit or implicit character, the choice of a normative criterion for decision making suffers the lack of a meta-theory for normativity: choosing among competing normative bases means choosing between concepts such as environmental justice, equity, emancipation, participation, federalism, accountability, (deep) ecology or sustainability, just to name a few. None of these criteria is per se more desirable than any other, though. A regulator is in a position to choose arbitrarily among them or to engage in deliberation exercises with a constituency. Either approach has its caveats, as testified by the growing body of literature on participation in public decision making (Abels 2007; Beierle 2000; Hagendijk and Irwin, 2006; Blackstock et al. 2007).

The choice of a normative basis for a resource regime, whether it is achieved in a more or less participatory fashion, will have consequences for the different features of the arrangement at stake: such features encompass those specific rules, norms and conventions (Crawford and Ostrom, 1995) which, bundled together, outline the institutional setting and determine its distributional performance. The literature on the commons has gone a long way in analyzing and systematizing the characteristics of the bundles of rules that have historically emerged among interdependent users. Under the header of "Design Principles", Ostrom (1990) proposes a seven-fold taxonomy focusing on 1) actors, 2) positions, 3) allowable actions, 4) scope, 5) choice, 6) information and 7) pay-offs. Additionally (8), rules concerning the way resource regimes nest on one another can become relevant on the basis of the resource complexity. Governance arrangements that have ensured the long-term survival of common pool resources contain provisions for all of these categories.

In summary, the prescriptions one can derive from the concept of interdependence, in the light of its roots in institutional ecological economics, focus on making the normative basis of resource regimes explicit so as to allow a broad societal debate about the distributional implications of the chosen arrangements. Dealing with common pool resources, governance arrangements can rely on a set of design principles aimed at ensuring the long term survival of the resource at stake.

The case in Venice Lagoon

Venice Lagoon is located at the lower end of the Padan Plain, in North-Eastern Italy. It is the country's biggest and most important lagoon ecosystem, testified by the high number of Special Protection Areas it encompasses, both on the basis of EU and national regulations: a high diversity of species, of which many are rare and endangered, finds a habitat in the lagoon.

Lagoons survive on a delicate balance between sedimentation and erosion. For Venice Lagoon, the "natural course of events" is unlikely to be a long-term equilibrium between the two tendencies but rather one of sedimentation or of transformation into a delta area similar to the Po delta some kilometers to the south.

Human intervention altered this course through river diversions roughly 400 hundred years ago (APAT / Environmental Protection and Technical Services Agency, 2006), pushing the lagoon towards erosion: the lagoon bottom loses yearly millions of cubic meters of sediments, becoming thereby deeper and flatter and allowing the salinity gradient to push further upstream. As the lagoon becomes deeper and more salty, ecological niches are lost and the resident species give way to different ones that better cope with the changed conditions, losing in turn their role in stabilizing the sediments. In such a process, the ecosystem as a whole moves away from the characteristics of a lagoon and approaches those of a sea arm (Day et al. 1999).

A re-diversion of the rivers into the lagoon is today not an option, due to both declined sediment transport and water quality considerations. Human intervention needs therefore to find ways to compensate the reduced push from the upstream watershed, partly mitigating and partly adapting to the new circumstances.

Crucial in this is the overall impact of human activity on the lagoon: intentional engineering interventions must be looked at in the light of economic and recreational activities. Such activities heavily rely on a variety of ecosystem services provided by the lagoon, while they contribute to both erosion and water and sediment quality degradation. The latter, beside the consequences it has on its own account, complicates recovery interventions and mitigation measures. The subsidence induced by groundwater extraction, finally, amplifies the impacts of erosion on both ecosystem and economic activities.

Let us at this point introduce the diversity of economic activities in Venice Lagoon and provide an illustration of the complexity of their interrelations mediated by the ecology of the lagoon. These are:

- **Tourism:** Venice and its surroundings are a tourist attraction of world-wide importance. We understand the presence of tourists to affect the number of boats floating in the lagoon for both transportation (including cruise ships) and recreational purposes (smaller boats, with or without engine). Boat traffic leads to erosion through wave action. Furthermore, the presence of large cruise ships in the lagoon is made possible by dedicated shipping channels which drain sand out of the lagoon and thus contribute to erosion. Furthermore, the increased use of sanitation facilities causes water quality issues due to insufficient wastewater treatment and subsidence through increased groundwater abstraction for drinking water production purposes. Flooding, on its part arguably reduces tourist activity by making amenities temporarily inaccessible and by deterring occasional tourists.

- **Petrochemical Sector:** the large refineries at the edge of the lagoon are accessed by large-scale tankers through the shipping channels mentioned above. Such large tankers contribute to erosion though the shipping channel per se as well as through wave action. Besides, the runoff of chemicals from the refineries into the lagoon water affects water quality. Water quality, in turn, affects sediment quality, which creates problem to the refineries whenever the sediments in the shipping channels are too polluted for the regular maintenance dredging. In that case, refineries are partly unreachable or reachable only by smaller tankers. Furthermore, restrictions on ship traffic for flood protection also constrains the refineries' activity.
- **Logistics:** the Port of Venice is an important logistics hub for trade between northern Italy and the Mediterranean. It affects erosion and water quality in ways similar to the refineries (even though the amount of runoff polluting the lagoon water is no match for that of the refineries).
- **Fisheries:** Venice Lagoon is famous for its cockle production. Cockle fisheries in the lagoon take place in a fully mechanical fashion, featuring trawlers which dredge the lagoon bottom with suction devices. Such suction devices significantly damages the morphology of the lagoon's bottom, contributing heavily to erosion. On the other side, fishing is restricted to certain areas only, due to water quality considerations (toxic pollutants accumulating in the cockles' tissues).
- **Agriculture:** agricultural production both within the lagoon (on certain islands) and on the lagoon's surroundings is a typical source of nutrient runoff, thereby affecting water quality and causing eutrophication.
- **Households:** households affect the lagoon ecosystem in ways similar to those of the tourism sector. It has to be noted though, that households are present both in the historical centre (the "island" of Venice) as well as along much of the lagoon gutter (Mestre most of all, but also Chioggia). These latter households are arguably less affected by flooding compared to the insular ones. Both types of households are however reliant on water quality and sediment quality for their recreational activities in the lagoon.[1]

Let us summarize the above in Table 1 below.

A situation emerges where economic sectors and the ecosystem affect each other in complex ways – the very notion of economy and ecosystem as two separated entities becomes questionable. In the following section we analyze the implications of the theoretical discussion presented above for the design of a governance structure able to deal with a similar degree of complexity.

Prescriptions in comparison

In order to proceed to the actual comparison, we need to establish a common language between the two concepts of externalities and interdependence through an analytical translation of Table 1. Externalities arise whenever a party's actions result in costs or

Table 1 Mutual relationships between ecosystem and socio-economic system

Sector	Affects	Is affected by
Tourism	Erosion, water quality degradation (point-source), subsidence	Flooding
Petrochemical Sector	Erosion, water quality degradation (point-source and diffuse)	Erosion, sediment quality degradation (through water quality), flood prevention
Logistics	Erosion, water quality degradation (diffuse)	Erosion, sediment quality degradation (through water quality), flood prevention
Fisheries	Erosion	Water quality degradation
Agriculture	Water quality degradation (diffuse)	None
Households	Erosion, water quality degradation (point source), subsidence	Flooding (historical centre only), water and sediment quality degradation

benefits not borne by themselves: we therefore begin (Step 1) by deriving cost functions for the different sectors as shown below:

$$c_t = f(k_t, F)$$

$$c_p = f\left(k_p, E, S, FP\right)$$

$$c_l = f(k_l, E, S, FP)$$

$$c_m = f(k_m, Q)$$

$$c_a = f(k_a)$$

$$c_h = f(k_h, F, Q, S)$$

The subscript indicates the sector involved: t = tourism, p = petrochemical sector, l = logistics, m = mechanical cockle fishing, a = agriculture, h = households. Concerning the arguments of the cost functions, variables are: E = erosion, F = flooding frequency, Q = water quality degradation, S = sediment quality degradation, FP = flood protection; k is meant as an aggregate measure of capital capturing the vector of production factors a sector hires on the market. Such variables cause production costs for the different sectors to rise as indicated in the description of each sector that preceded Table 1. With the exception of k, we define them as environmental factors.

Below (Step 2), we rearrange the content of the first column of Table 1 along with the environmental factors; by doing so, we indicate the production level of the different sectors using the same labels provided above, though in capital letters. Beside the already mentioned factors, D indicates subsidence (caused by but not directly affecting sector production).[2]

$$E = f(T, P, L, M, H)$$

$$Q = f(T, P, L, A, H)$$

$$D = f(T, H)$$

$$S = f(E, Q)$$

$$FP = f(E, Q, S, D)$$

$$F = f(E, D, FP)$$

With the above, we have simply reorganized the contents of Table 1 by impact instead of by sector. We see for example that erosion (E) is cumulatively caused by tourism (T), the petrochemical sector (P), the logistics sector (L), the mechanical cockle fishery sector (M) and by households (H). Water quality, for its part, is affected by the same sectors also causing erosion, however including agriculture (A) and excluding cockle fisheries (M). The same is true for all other sectors.

Substituting the above in the cost functions (Step 3), the externalities become evident:

$$c_t = f\left(k_t, T_E, P_E, L_E, M_E, H_E, T_Q, P_Q, L_Q, A_Q, H_Q, T_D, H_D\right)$$

$$c_p = f\left(k_p, T_E, P_E, L_E, M_E, H_E, T_Q, P_Q, L_Q, A_Q, H_Q, T_D, H_D\right)$$

$$c_l = f\left(k_l, T_E, P_E, L_E, M_E, H_E, T_Q, P_Q, L_Q, A_Q, H_Q, T_D, H_D\right)$$

$$c_m = f\left(k_t, T_E, P_E, L_E, M_E, H_E, T_Q, P_Q, L_Q, A_Q, H_Q, T_D, H_D\right)$$

$$c_t = f\left(k_m, T_Q, P_Q, L_Q, A_Q, H_Q\right)$$

$$c_a = f(k_a)$$

$$c_h = f\left(k_h, T_E, P_E, L_E, M_E, H_E, T_Q, P_Q, L_Q, A_Q, H_Q, T_D, H_D\right)$$

where k_t, k_p, k_l, k_m, k_a and k_h, indicate the production factors employed by the sectors identified in capital letters, while all other arguments capture the contribution of the indicated sector to the given environmental factor in subscript.[3]

We choose now to indicate with K the specific vector of market-hired production factors employed by every sector; by doing so, we separate in a clearer way the "internal" from the "external" components of the cost function. Despite a certain loss of precision (the actual extent of which depends on the algebraic construction of the cost functions), the above can be summarized (Step 4) as in Table 2.

In order to establish a nexus to welfare, a utility function for the average citizen can be specified in the most general case as:

$$u = f(T, P, L, M, A, H, FP, F, E, Q, D, S)$$

Utility is thereby captured by the given production vector Y ≡ {T,P,L,M,A,H}, by the vector of environmental factors EF ≡ {E,Q,D,S}, by the frequency of flooding F and by the level of flood protection FP. Within the production vector, M and A can eventually be omitted under the assumption of their marginality within the national markets for agricultural and fishing produce, while the environmental factors may or may not appear according to (assumptions over) their perception[4] by the average citizen.

Table 2 Cost functions by sector

Tourism (T)	$c_t = f(k_t, T, P, L, M, A, H)$
Petrochemical Sector (P)	$c_p = f(k_p, T, P, L, M, A, H)$
Logistics (L)	$c_l = f(k_l, T, P, L, M, A, H)$
Mechanical cockle fishing (M)	$c_m = f(k_m, T, P, L, A, H)$
Agriculture (A)	$c_a = f(k_a)$
Households (H)	$c_h = f(k_h, T, P, L, M, A, H)$

Table 2 shows in analytical terms that basically all sectors affect one another through their effects on the environmental factors – this is the definition of interdependence. To which extent they do so depends on the maths of the cost functions, in turn depending on the set of simplifications an analyst is willing to make in order to ensure the mathematical tractability of the problem. Given that our primary goal is to illustrate the complexity of the issue, we will at this point restrain ourselves from making assumptions about the shape of either cost or utility functions, and leave an analytical proof of the superiority of either Coasean or Pigouvian approaches to colleagues with a stronger interest in modeling.

Whether ecological-economic modeling is capable, at the present state of knowledge, to describe with a sufficient degree of reliability both cost functions and marginal substitution rates so as to derive an optimal Pigouvian tax for every sector, is an open question. Furthermore, whether this capability extends to the economic sectors for them to autonomously engage in multilateral Coasean bargains and reach efficient levels of E, Q, D and S, will be left open.

What is clear is that, by involving whole sectors, marginality cannot be invoked: whatever change in the configuration of E, Q, D and S redistributing the abatement across firms and sectors will certainly alter the relevant set of prices determining which abatement package is the least-cost one. This makes the assessment of Coase's "total social product" problematic: choosing any arrangement relying on prices knowing that those very same prices depend on the arrangement chosen is either tautological or biased towards the status quo, as Vatn (2002) points out.

Let us now consider that both Coasean and Pigouvian approaches. As they are both centered on efficiency reasoning, their rationale lies in achieving an efficient level of environmental factors through market mechanisms. This means that no mandatory level of environmental quality is prescribed or even envisioned; instead, the task is shifted to production activities to reach, through internalization (Pigou) or mutually beneficial bargains (Coase), an "equilibrium" configuration whose desirability against any other is granted by relative prices being equal to relative marginal utilities.

Obstacles to this can emerge on the ground of the attribution problems that may arise in Step 2 and prevent Step 3 from taking place. If it is not possible to derive the impact of each sector's activity level on the environmental factors E, Q, D and S, sectors are caught in a collective action problem as disturbances become for them a commons – the additional costs caused by the environmental factors might be known, but not the sectors that contributed to them. Individual impacts become thus cumulative effects – an issue enjoying large scholarly attention (Andersen et al. 2017; Masden et al. 2010; Mach et al. 2017; Thébaud et al. 2015), yet still posing methodological and operational challenges to both academics and practitioners (Foley et al. 2017; Huang and London 2016; Sinclair et al. 2017).

What is more, if valuation exercises fail to track the direct effect of the environmental factors on the individuals' utility functions, the link between the equilibrium configuration and the aimed maximization of welfare is severed. The configuration the market under either a Pigouvian or Coasean arrangement would reach in this case is by no means necessarily a desirable one – representing a Quasi-Pigouvian and/or Quasi-Coasean arrangement instead. The further the resulting externality is from efficiency, the greater the incentives towards additional Coasean bargains among affected parties. Dealing however with a cumulative effect, such bargains would resemble deliberations within complex multilateral agreements rather than market transactions, defeating the purpose of employing economic instruments to address the externality.

Prescriptions from the side of the interdependence literature start precisely from this point as they are derived in a context of weak comparability and social construction of value for the resolution of conflicts where full and complete demarcation is precluded. Far from aiming at "efficient" arrangements, they foresee a societal debate aimed at normatively identifying those elements of the trade-off that will inform the choice. This will translate not only into a given level of environmental quality, but also into a specific production vector identified as socially *desired*, both of which emerge as a socially constructed product of deliberation.

The question is indeed not only one of trading off the production space (that is the set of all production vectors compatible with a given configuration of the environmental factors) with a desired level of E, Q, D and S in a situation of missing markets for the latter; the choice is both deeper and broader as it involves trading off environmental factors with one another while envisioning the desired configuration of the production vector.

Intrapersonal incommensurability implies that these trade-offs cannot be made individually even when relative prices are available, so that independent individual choices cannot be relied upon when aiming at socially desirable outcomes. A regulator is therefore recommended to relate decisions to a discussion within civil society and to the structures of political representation rather than to market mechanisms: facilitating such discussions within a given constituency means creating platforms able to decide on those arrangements, allowing the different sectors to affect how much of E, Q, D, and S they consider it worthwhile to achieve. More specifically, the possibility shall be provided to make decisions concerning the thresholds for the environmental factors, while discussions with, within and among the sectors shall identify the normative criteria for the room given to T, P, L, M, A and H respectively.

We can therefore wrap up by saying that, if attribution and valuation problems are acknowledged, prescriptions based on the concept of externality become problematic and leave room for prescriptions envisioned within the interdependence literature. The consequence is that a normative identification of both an acceptable degree of environmental disturbance and of a desired production factor translates into a regime of democratically guided, direct regulation of the degree of pressure economic activities are allowed to exercise upon the lagoon's ecosystem.

The current regulatory framework

The above section has critically reviewed prescriptions the externality and interdependence literature have to offer for the case of Venice Lagoon. Let us now assess the "distance" between such prescriptions and the current regulatory framework. The lagoon ecosystem is subject to a multiplicity of regulations emanating from different layers of socio-political organization; they constitute a case for Multi-Level Governance (Bache and Flinders, 2004), where institutional interplay (Young 2002) represents a major challenge to both decision-making and implementation.

The overarching piece of regulation is the European Water Framework Directive ("EWFD" in the following), intertwined with Birds Directive and Habitat Directive:

cumulatively, and in a gross simplification, these regulations entail the substantial prescription of achieving good ecological status of the lagoon's waters and of the Special Protection Areas therein. Besides, functional prescriptions concern a certain degree of cost-transparency, a withdrawal from sectoral cross-subsidization in water services (not in water uses), a certain degree of participation in the definition of measures and a certain extent of subordination of economic interests to environmental objectives.

At the national level the Ronchi-Costa bundle, a set of environmental laws, prescribes special environmental standards for the lagoon in terms of water quality, sediment quality, effluent quality and industry standards, while at the sub-national level, the Protocol 93, a multi-level agreement limited to the extent of the lagoon, sets the terms for sediment relocation in the lagoon.

Moving now more explicitly towards the economic sectors, we find that technical requirements regulate the vast majority of the impacts. Concerning erosion (E), navigation rules and construction standards for the large and small scale ships constitute the only nexus between the sectors' activity level (T, P, L, M, H) and the amount of navigation induced erosion $E = f(E_T, E_P, E_L, E_M, E_H)$. No upper bound is foreseen at either sectoral or firm level, exception is made for E_M, which is, though, not respected due to weak enforcement capacity.[5]

Water quality degradation is similarly dealt with through effluent quality standards (point sources) and safety regulations and technical requirements (diffuse sources) as far as the contributions of the petrochemical sector (Q_P), logistics (Q_L) and agriculture (Q_A) are concerned. Drinking water and wastewater fees represent, instead, the nexus between the activity level of tourism and households and their respective contribution to water quality degradation (Q_T and Q_H) and subsidence (D_T and D_H). Again, neither case foresees any upper boundary.

It is also worthwhile mentioning that all sectors are equipped with market entry barriers: this does affect the number of firms within a sector but does not, as such, represent a cap to the sector's activity level, it does not, therefore, affect the overall impact of the sectors.

Arrangements are summarized in Table 3.

We can identify a regulatory challenge in the absence of upper bounds on the impacts of most sectors: this circumstance clashes with the responsibility of the authorities to meet the goals of both EWFD and the Ronchi-Costa special legislation. While the latter prescribes a (rather) stringent level of water and sediment quality, the EWFD indirectly imposes constraints on the total level of E, Q, D and S. Only certain combinations of the environmental factors are indeed compatible with a good ecological status: even though a certain, limited degree of substitution among them should be acknowledged, the achievement of a good ecological status for the lagoon's water poses implicit upper bounds to E, Q, D and S as they are functional for the preservation of the lagoon's many ecological niches and have to be compatible with their tipping points.

Official assessments of the compliance to the EWFD find that most of the lagoon is in a condition of poor ecological status due to morphological issues (erosion and subsidence) and nutrient loads in both water and sediments (see APAT / Environmental Protection and Technical Services Agency, 2006; in particular Carrer & Ferrari, pp. 732–741 and 690–708 respectively). This signals that the current level of E, Q, D and S are beyond what

Table 3 Regulation approach of the impacts on environmental factors by sector

Sector	Impact	Regulated through
Tourism (T)	E_T	technical requirements
	D_T	water fee
	Q_T	wastewater fee
Petrochemical Sector (P)	E_P	technical requirements
	Q_{Pp}	(point source) effluent quality standards
	Q_{Pd}	(diffuse) technical requirements
Logistics (L)	E_L	technical requirements
	Q_L	technical requirements
Mechanical cockle fishing (M)	E_{Ma}	(authorized) technical requirements + upper limit to harvesting effort
	E_{Mu}	(unauthorized) unregulated
Agriculture (A)	Q_A	technical requirements
Households (H)	E_H	technical requirements
	D_H	water fee
	Q_H	wastewater fee

is compliant with the EWFD. This implies that for the current level of economic activities, the technical efficiency requirements are too low. A symmetrical reading would be that, given the current abatement capacities, the production activities are altogether too intensive: a combination of higher abatement efforts and reduced economic activity are needed for the EWFD and the Ronchi-Costa goals to be achieved.

There is a case for abatement and opportunity costs respectively to be distributed over the sectors through trade-offs among the sectors' activity levels. The theoretical discussion above has outlined the consequences of approaching such distribution as suggested by the two concepts of externality and interdependence. Authorities seem to have approached neither way as erosion is currently addressed through iterative morphological reconstruction, while much of the achievements in terms of reduced nutrient inputs through increased abatement efficiency have been possible only through public subsidies.

National funds are made available for interventions, shifting abatement costs entirely onto the national taxpayer. The resulting transfer of wealth embodies an implicit trade-off between eroding national public funds and preserving local private revenues. Posing the question of Paretian efficiency at this stage requires the non-trivial possibility of comparing the added value of the production vector with the costs of the remediation efforts. If instead weak comparability is acknowledged, the question becomes one of characterizing the context where the same trade-off is or can be decided upon.

A regulatory gap emerges herewith as remediation activities in the lagoon are dealt with as a technical and not as a normative issue: a special agency, the Venice Water Authority (Italian acronym: "MAV") is entrusted with those activities, relying on national funding. However, this agency holds no regulatory powers over the economic sectors, neither does it have the legal right to intervene in economic policy or have a say in the extent and modes of economic production in the lagoon. These are the remit of local governments in and around the lagoon, whose relationship with MAV is very often adversarial and certainly not one of close cooperation.

MAV has apparently little or no control over the requirements listed in Table 3, as they emanate from different policy areas at different levels. Choices over these arrangements are arguably made independently of one another. We have here a blend of heterogeneous safety and technical standards, some local and some international, that cannot be considered tailored to the explicit objective of reaching a good ecological status in Venice Lagoon given a certain level of economic activity.

The set of regulations in Table 3 can only by chance lead to a good ecological status by itself. As MAV has no influence on them, it finds itself in the position of having to take them as given and compensate for the difference. In the trade-off between remediation effort and economic activities, an implicit protection of the latter is the result, while a context for settling this normative decision is missing altogether, as well as a context for trading off activities against one another, be it through market forces or through public intervention. As the trade-offs at stake are dealt with as technical issues, they are settled implicitly instead of being made explicit.

In light of the EWFD and its prescriptions on cost transparency, cross-subsidization, participation and subordination of economic interests, the resulting transfer of wealth is, at the very least, questionable. In order to conceptualize a situation where the maintenance of Venice Lagoon is a task for the economic sectors in Venice Lagoon and not for the central state, the economic perspectives articulated so far can provide some help.

From the point of view of the externality literature, the problem is one of achieving an efficient configuration of T, P, L, M, A, H which is compatible with the upper boundaries placed on E, S, D and Q.[6] Quasi-Pigouvian approaches would focus on aligning production vectors and environmental factors through targeted taxation, such as emission charges and ambient taxes. A quasi-Coasean approach would instead translate into a cross-sectoral trading permit scheme for activities detrimental to E, S, D and Q with a movable cap. From an interdependence perspective, sectors deprived of the abatement currently performed by the water authority are left with a complex common pool resource represented by the lagoon ecosystem. If economic sectors were to prove incapable of cooperating and collectively respecting some upper boundaries for E, S, D and Q, the water authority would not be able to avoid rationing measures in order to comply with EWFD and Ronchi-Costa. This would necessitate, in other words, the imposition and enforcement of caps on the activity of the different sectors.

Translating Ostrom's design principles to the case of Venice Lagoon, self-interested actors (the economic sectors) aiming at the long-term maintenance of their resource basis (the lagoon) need to define rules pertaining to: 1) sector-wise entry and exit of firms affecting the specific environmental factor; 2) joint decision-making across all sectors; 3) technical requirements; 4) the spatial boundaries of the effects of the regime; 5) degree of freedom in accessing the resource; 6) the treatment of information; and 7) pay-offs to firms. Additionally (8), rules concerning the way resource regimes relate to one another become relevant on the basis of the resource interdependence highlighted above. Seen in these terms, the current regulatory framework as summarized in Table 3 provides only a partial coverage, as most regulation pertain to domain 1 and 3, while the rest is left blank, most notably under domain 5. This allows for a de facto open access regime among competing economic sectors.

Conclusions

A two-way connection between ecosystem and socio-economic system has been explored for the case of Venice Lagoon. The analysis has been informed by different branches of economic theory, introducing the perspectives of environmental and ecological economics. Prescriptions from both fields were compared with one another and applied to the case, highlighting their different application fields. Subsequently, the current regulatory framework was evaluated from the point of view of both perspectives, identifying the regulatory gaps that force the water authority into its current passive role.

The sense of the metaphor in the title can now be revealed: since all actors in the socio-economic system affect one another by competing for ecosystem features, they are "all in the same boat" in the sense that they share a destiny embodied by the preservation of the lagoon ecosystem from which they all depend. Both environmental and ecological economics converge on this point.

The extent of such dependence has been so far hidden through the regular interventions of the water authority and the transfer of wealth they imply: this possibility, currently insufficient, might prove incompatible with European regulations. Sooner or later, the socio-economic system will face the challenge of having to restructure itself so as to stay within the possibilities allowed by the ecosystem without the visible hand of the water authority, paid for by the rest of the country.

The prescriptions from both environmental economics and institutional ecological economics have been then translated to the specifics of a the lagoon's challenges. As the comparison has highlighted a divergence in the set of assumptions underlying either approach, an ultimate judgement on the superiority of either perspective lies in the adherence of the Venetian context to one or the other set. Conversely, it has been shown that the reliance on the performance of either set of prescriptions reflects implicit views concerning society and the environment; we can therefore recommend decision-makers to verify which set provides a better description of the socio-economic and ecological environment they work with prior to endorsing either (or any other) approach.

That said, a word of caution is due. Both fields of inquiry relied upon for this analysis (the externalities literature and the interdependence literature) are far from conclusive and have only heuristic value in practical applications. Both of them have done us a good service in highlighting the complexity of the matter – in theory as well as in practice. Yet, a final answer on how to best govern Venice Lagoon is still far away. Ultimately, we only suggest to make explicit those transfers of wealth that are currently taking place implicitly between sectors and from the state to the lagoon.

Besides, the present analysis has only provided us with a glimpse into the complexity of the lagoon socio-ecological system. For example, our treatment of the different sectors has been coarse, to say the least. Our treatment of the lagoon's ecosystem, furthermore, only considers a small set of physical interdependencies, whereas ecosystem behavior, feedback loops, temporal considerations and the very status of the lagoon are by far more complex than how we portrayed them here.

In our defense, it is hard to imagine how more complexity could overturn our findings, but the point still holds that addressing the issues raised here while doing justice to the complexity of the situation is more likely to resemble a research program than a single contribution. We would therefore certainly recommend systemic approaches to further research on Venice Lagoon: input–output models and computable general equilibrium models coupled with lagoon ecosystem models certainly have the potential to generate insights into different possible future scenarios. At the same time, sociological and anthropological work is needed in order to capture the reality of the lagoon as a social context. Insights from both sides may then be channeled into deliberative exercises eliciting the normative dimension of choices affecting the various actors involved.

Ultimately, they are all in the same boat: wherever they'll go, they'll go together.

Endnotes

[1]Other than tourists, residents are exposed to the lagoon's environmental quality all year round. Pollutants in the lagoon's waters and sediments that are of no concern for the occasional tourist constitute a relevant issues for those being exposed to them all year round.

[2]The separate operationalisation of F and FP is necessary in the light of their antithetic contribution to the sectors: tourism is for example negatively affected by flooding, hence positively affected by flood protection measures; logistics, instead, is not affected by flooding per se but is nonetheless negatively affected by flood protection measures through the reduced accessibility of the lagoon they cause. In turn, through FP, F becomes dependent on quality issues such as Q and S: water and sediment quality would not per se affect flood frequencies, making F only dependent on the degree of erosion (E) and subsidence (D);

[3]Meaning that L_E captures the contribution to erosion by the Logistic sector producing at level L.

[4]The dimension of perception is the reason why F and FP appear simultaneously and together with the environmental factors. In step 3, F and FP enter the cost functions through their drivers and are implicitly reduced to them as the point is to disentangle relative contributions of the factors involved. A similar perspective does not extend to utility functions: an individual can experience disutility through F and, say, E on their own account, even if part of the disutility s/he experiences through F is indeed caused by the level of E. Ecosystem knowledge can elicit the mutual relationship between F and E; the individual, though, experiences them separately and not even necessarily in physical terms. Double counting is in these terms not relevant.

[5]Unauthorised harvesting is widespread.

[6]Please note that F is here a function of E, S, D and Q, while FP as a measure of mitigation of induced F is zero if the desired level of environmental factors is to be achieved through market forces only.

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