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Analysis

# Environmental Governance Dynamics: Some Micro Foundations of Macro Failures<sup>☆</sup>

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## ABSTRACT

This article proposes a new theoretical explanation to the question of environmental governance failures, combining micro and macro explanations in the long run. We put forward the concept of Transversal Transaction Costs (TTCs) as a critical source of governance failures. TTCs are transaction costs induced by interlinkages between public policies and property rights, an area under-investigated by the natural resources governance literature. We emphasise that TTCs are consequential in limiting the ability of environmental governance to coordinate natural resource uses. Drawing on institutional complementary and cluster literature, we argue that TTCs increased significantly over the years shaping governance evolution at the macro level in the long run. We show that institutional resource regimes tend to get locked into an Institutional Complexity Trap (ICT), which prevents improvement in coordination capacity and explains the persistence of environmental governance failures. Four cases substantiate our conceptual proposition of transversal transaction costs. In addition, the process-tracing of six water governance cases in Europe from 1750 to 2004 provides empirical support to the macro dynamics of institutional complexity trap.

## 1. Introduction

Institutions strongly determine human behavior and our impact on the environment. As rules of the game, institutions shape actors behaviors by creating a framework of incentives and legitimating choices (North, 2005; Vatn, 2005). Institutions, such as public policies and property rights<sup>1</sup>, make up the formal components of governance, and their outcome is the quality of the coordination of natural resource uses. In that respect, institutions – particularly their design – constitutes a central issue for sustainability and sustainable uses of natural resources. Consequently, current research pays attention to governance failures with an analytical lens focused on institutions (Bromley, 1991; Derwort et al., 2018; Folke et al., 2007; Howlett and Ramesh, 2014; Ostrom, 2005; Vatn, 2005).

For over a decade, scholars and practitioners have put forward the need for integration to prevent governance failures (Jordan and

Lenschow, 2010). Integration refers to a holistic governance design that takes into account a variety of uses (Tosun and Lang, 2017; Trein et al., 2018). It is argued that regulating more and more uses integrates governance and should lead to better policy outcomes. For instance, the Integrated Water Resource Management emphasizes the need to consider jointly multiple water uses, such as from agricultural, energy and urban sectors, to improve water quality. But sustainability issues persist. For instance, only 40% of European surface waters reach a good ecological status (EEA, 2018). Regarding that case, the literature focuses on the implementation of policy tools and recent studies put forward the systemic effect of the implementation of the EU Water Framework Directive (Bolognesi, 2014; Voulvoulis et al., 2017). It emphasizes that, despite the significant role of integration in environmental policy analysis and practice, there is still a need to understand integration processes (Candel and Biesbroek, 2016; Persson and Runhaar, 2018).

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<sup>1</sup> We focus on formal institutions defined as public policies and property rights (Gerber et al., 2009; Vatn, 2005).

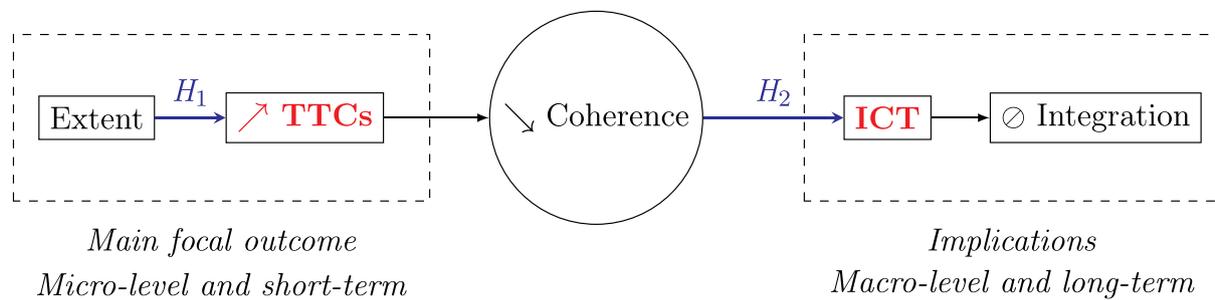


Fig. 1. Focal of the paper.

The Institutional Resource Regime (IRR) framework allows for the diagnosis of the evolution of governance integration regarding public policies and property rights (Gerber et al., 2009; Knoepfel et al., 2007; Varone and Nahrath, 2014). Using this framework, we define integration as an Institutional Resource Regime, i.e., a governance design regulating uses of a given natural resource, with a high extent and a high coherence. By extent, we refer to the number of uses regulated by the regime, i.e., the quantity of public policies and property rights, and by coherence to the clarity and the compatibility of public policies and property rights that make up the regime, i.e., the quality of institutions. Consequently, an integrated regime covers all the uses of a natural resource in an efficient way, which is expected to prevent from governance failures and contribute to sustainability (Gerber et al., 2009; Knoepfel et al., 2007). The paper deals with the process of integration, aiming at identifying preventing factors.

Barriers to integration are numerous. Rules can be contradictory because of overlaps and interplays (Jacobi, 2017; Moss, 2004; Young, 2010; van den Bergh et al., 2011), which in turn negatively affects the efficiency of enforcement (Bolognesi, 2014; Saleth and Dinar, 2008), incentives mechanisms (Feiock, 2013) or planning clarity and feasibility (Correljé et al., 2007). Authors mainly focus on the impact of institutions on actors behaviors showing the critical role of transaction costs (TCs) (Krutilla and Alexeev, 2014; Krutilla and Krause, 2010; McCann et al., 2005; Phan et al., 2017). TCs could prevent actors from complying by making coordination too complex and unclear (Lubell et al., 2017). The understanding of the structure of TCs has significantly increased during the last decade (Furubotn and Richter, 2005; Marshall, 2013; McCann et al., 2005), but their impacts and evolutions in a dynamic settings remains under-investigated.

We focus on transaction costs associated with the evolution of the regime extent to offer an explanation to the raising of barriers to integration. IRR case studies, among others, show that most of natural resources governance designs have experienced historical trajectories leading to incoherencies as their extent increased (e.g., the implementation of new policy instruments, the definition of new property and use rights) (Gerber et al., 2009; Kissling-Näf and Kuks, 2004; Knoepfel et al., 2007; Varone and Nahrath, 2014).

We propose the concept of Transversal Transaction Costs (TTCs) to offer a theoretical explanation to this established diagnostics (Fig. 1). The attribute transversal refers to interlinkages between public policies, i.e., public law, and property rights, i.e., private law. For instance, there are contradictions between land use planning and land ownership guarantee in Switzerland.<sup>2</sup> To our knowledge, TTCs have not been identified yet in the literature. We argue that increasing regime extent, i.e., expanding the scope of the governance design, generates TTCs among the components of the regime and limits the efficiency of each new institution ( $H_1$ ). Exploring the impact of TTCs at the regime level in the long run, we argue that TTCs reduce the coherence of the regime. Further, TTCs multiply overtime as the governance scope extends, they lock the regime into an Institutional Complexity Trap (ICT), which

prevents its integration ( $H_2$ ). The ICT situation is one where TTCs equal the positive impact of the extent on integration. Overall, TTCs cause a decreasing marginal effect of extent on integration, which explains the numerous empirical observations of governance failures in the long run.

By developing the concept of TTCs, this article aims at providing a theoretical answer to the persistence of governance failures in the long run, i.e., ICTs situations. The paper is structured in five sections. Section 2 offers the theoretical background for the two concepts we put forward. Sections 3 and 4 present the methodology and the results related to TTCs and ICT. Section 5 summarizes our main findings and discuss their implications for the understanding of environmental governance dynamics.

## 2. Theories and hypotheses: transversal transaction costs beyond sequential transaction costs

### 2.1. Significance of transaction costs in natural resource governance: a sequential perspective in the literature

Transaction Costs Economics (TCE) entered the field of natural resource management firstly to appraise environmental policies (dis) functioning, especially in the water sector (Challen, 2000; Hanna, 1995; McCann et al., 2005). Recent developments in this field place the focus on the life-cycle of a given environmental policy. The aim is to identify mechanisms that cause policy reforms outcomes to fall short of expectations (Coggan et al., 2010; Krutilla and Krause, 2010). McCann (2013) disentangles physical and institutional factors that affect transaction and abatement costs which in turn shapes policy design efficiency; this allows for the ascertaining of appropriate policy instruments sequencing. The ability of TCE to compare different policy designs proves to be fruitful in highlighting advantages and limitations of policy instruments regarding social efficiency (Finon and Perez, 2007), participation (Lubell et al., 2017), monitoring (Rendón Thompson et al., 2013), compensation design (Levrel et al., 2017) or market allocation efficiency (Garrick et al., 2013) in various sectors.

Empirical assessments point out the impact of TCs on environmental governance efficiency. These assessments mostly concern the costs of organizing good or service transfers (Cheung, 1992; Krutilla and Krause, 2010). As an illustration, because groundwater management requires a lot of information, water markets face high TCs, which are related to the long duration required to assess and approve lease transfers, coupled with many conditional restriction requirements (Wheeler et al., 2017). In most environmental governance designs, TCs are considerable and vary widely from case to case (Banerjee et al., 2017; Phan et al., 2017).<sup>3</sup> Garrick et al. (2013)'s review of TCs in

<sup>3</sup> It is noteworthy to remind the reader that the measurement of TCs remains complex and methodologically diverse (Krutilla and Krause, 2010; Sykuta, 2010; Wang, 2003). Nonetheless, a common proxy for TCs is the time spent by people on "non-productive" tasks related to the transaction, such as gathering information, monitoring and jumping administrative hoops. The direct cost of outsourcing these tasks could also be a proxy.

<sup>2</sup> Section 3 develops this case.

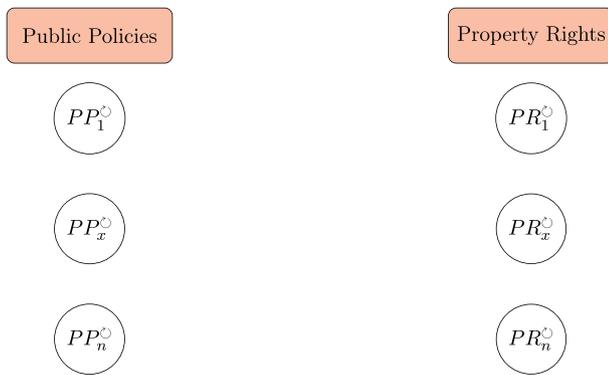


Fig. 2. Well-established static transaction costs.

emerging water markets confirms this statement. During the 1990s, TCs of water markets were about 10% in the US, in the range of 3%–29 % in Australia, and 7%–23 % in Chile. In the European agri-environmental policy, TCs represent 15% of the total cost of applying agri-environmental schemes, and about 25% of the compensation payment (Mettepenningen et al., 2009). In forestry carbon projects, TCs represent 17.6% of the market price (Phan et al., 2017). While they depend on the sector and context of the transaction as well as on the type of policy instruments implemented, TCs are high in environmental governance (McCann, 2013). Our review of empirical studies underlines that many different forms of TCs have been under scrutiny. A clear distinction separates static from dynamic TCs (Marshall, 2013). Static TCs embrace both market and managerial TCs and can be ex post or ex ante (Furubotn and Richter, 2005; McCann et al., 2005). They are also specific to each single institution (Fig. 2). Dynamic TCs occur when there is an institutional reform. They are linked to path dependency and technology, and are the potential product of an institutional transition, transformation, or substitution (Marshall, 2013).

Fig. 3 illustrates that the link between old and new public policies and property rights brings dramatic increase to dynamic TCs. Secondly, the Figure suggests a distinction between aggregate and marginal TCs in order to propose a fine-grained appraisal of the institutional change in a regime (Garrick et al., 2013). We stand on, and generalize, this remark. Whether they are static or dynamic, identified TCs relate to a specific measure (or policy instrument). Little attention is paid to the interaction with other institutions that impact the same resource, e.g., procurement market rules with drinking water price; water quality with hydroelectricity production and water ecosystems protection; urbanization with transport infrastructures, air protection and protection against noise.

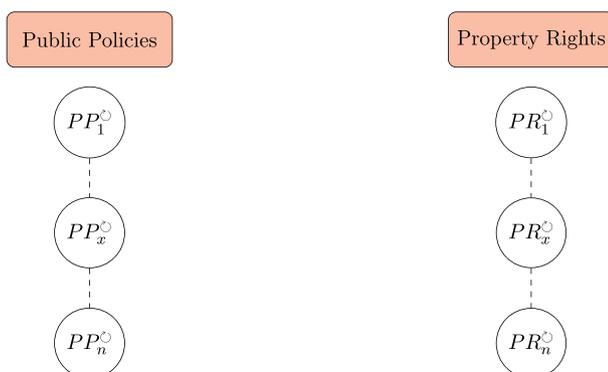


Fig. 3. Well-established dynamic transaction costs.

## 2.2. Inconsistencies between public policies and property rights: toward TTCs

In each socio-ecological system, an institutional regime shapes the co-evolution between the social and the environmental sphere. An institutional regime is a set of institutions dedicated to regulating uses of a given natural resource (Ostrom, 2009; Vatn, 2005). It combines public policies (PP) and property rights (PR) (Gerber et al., 2009). We define a property right as the right of an actor (the owner) to appropriate exclusively (i.e., to the detriment of all others) the benefit stream by a resource (Bromley, 1991). A public policy is a confirmation, a limitation, or a redefinition of property rights in favor of the public interest. Institutions generate both transaction costs and coordination capacities. Consequently, there is a trade-off between TCs and coordination capacities (Garrick et al., 2013; Williamson, 2000). This trade-off highlights that extent (E) and coherence (C) contribute together, and not independently, to the integration (I) of a regime (Gerber et al., 2009). Consequently, we note the integration of the regime *i* regulating the resource *j* as following:

$$I_{j,i} = E(PP_{j,i}, PR_{j,i}) \times C(PP_{j,i}, PR_{j,i}) \tag{1}$$

Coherence constitutes a central factor of the integration of an institutional regime. Three types should be distinguished: internal coherence of public policies, internal coherence of property rights and external coherence (cross-coherence of public policies and property rights). The siloisation of the European water policies into numerous subsectoral and specific policies during the 1990s illustrates internal coherence changes, e.g., the Directive 91/27/EEC on Urban wastewater and the Directive 91/676/EEC on Nitrates from agricultural sources (Bolognesi, 2014). External incoherence could be a misalignment between the target group of public policies and the actual property rights owners that are impacting significantly on the resource (Gerber et al., 2009). For instance, European water policies promote increasing tariff blocks to limit uses but they focus on households and do not frame tariffs structure for industries and agriculture, even if they represent the biggest individual consumers<sup>4</sup> and more than 75% of water consumption.<sup>5</sup>

The coherence is three-tiered and denotes the level of TCs related to each component of the regime:  $C_{j,i} = [\alpha \cdot PP_{j,i} + \gamma \cdot PR_{j,i} + \sigma \cdot (PP_{j,i} \cap PR_{j,i})]$ , where  $\alpha$ ,  $\gamma$ , and  $\sigma$  are TCs. Existing frameworks appraise the coherence of each components of the institutional regime, i.e., the internal coherence of public policies ( $\alpha \cdot PP_{j,i}$ ) and of property rights ( $\gamma \cdot PR_{j,i}$ ), by measuring the private, administrative or policy-induced transaction costs of specific institutions (see Appendix A). TCs induced by interactions between public policies and property rights, i.e., related to external coherence ( $\sigma \cdot (PP_{j,i} \cap PR_{j,i})$ ) are ignored while empirical analysis suggest they are consequential (Bolognesi, 2018; Bolognesi and Pflieger, 2019a; Varone and Nahrath, 2014).

Considering they source significant governance failures, we focus on the TCs related to external coherence, and precise the Eq. (1):

$$I_{j,i} = (PP_{j,i} + PR_{j,i}) \times [\alpha \cdot PP_{j,i} + \gamma \cdot PR_{j,i} + \sigma \cdot (PP_{j,i} \cap PR_{j,i})] \tag{2}$$

We argue that external coherence differs from internal coherence in that it depends on *Transversal Transaction Costs* (TTCs). Reciprocally, TTCs are specific to external coherence. We propose the term TTCs to emphasize their singularity which is they occur between property rights and public policies, i.e.,  $\sigma$  related to  $(PP_{j,i} \cap PR_{j,i})$ . Consequently, they are not specific to a given public policy or property right, but are related to interactions with pairs of public policies and property rights

<sup>4</sup> and thus should be more sensitive to increasing tariffs.

<sup>5</sup> see European Environment Agency assessment of sectoral uses: <https://www.eea.europa.eu/data-and-maps/daviz/annual-and-seasonal-water-abstraction-5#tab-dash-board-02>, accessed February 13, 2019.

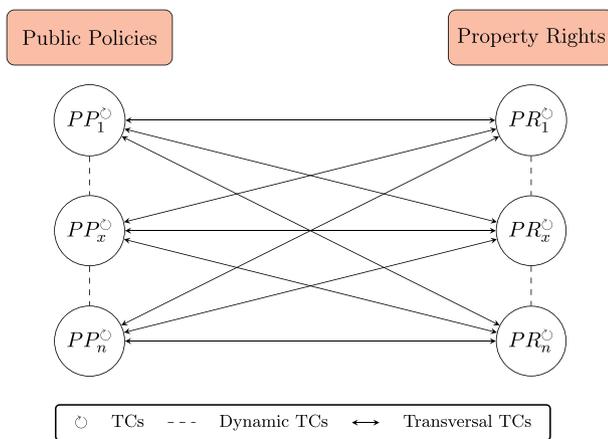


Fig. 4. The singularity of Transversal Transaction Costs.

(Fig. 4). Moreover, the term *Transversal Transaction Costs* (TTC) is meant to underline this fundamental difference with current transaction costs. The transversal characteristic makes TTCs dependent on the regime extent. It is when the regime extent increases that TTCs come up. It is when the regime extent increases that TTCs come up, as highlighted the web drawn in Fig. 4. New public policies or property rights are likely to interact with the existing one, producing unpredicted TTCs.

We formalize the previous proposition in the following hypothesis:

**Hypothesis 1:** The increase of regime extent produces transversal transaction costs among public policies and property rights, which corresponds to a decrease of the external coherence of the regime.

### 2.3. Theoretical delineation of transversal transaction costs: degrees of institutional complementarity

Institutions are not isolated but interact with a pool of pre-existing institutions from other domains. Aoki (2001, p. 223) shows that “an institution implemented in one domain will parametrically affect the consequences of the other game by changing its institutional environment”.<sup>6</sup> Institutions interact through institutional complementarities and cluster effects (Amable, 2016; Aoki, 2007; Höpner, 2005; Jellema and Roland, 2011). It implies that the integration of a regime could not be derived solely by the analysis of the sum of its components. Precisely, we defined TTCs concept to grasp complementarities and cluster effects at the micro level.

Saleth and Dinar (2008) give empirical evidence of institutional complementarities within the water sector. They analyze 26 institutional variables covering legal, policy, organizational and performance dimensions. Identifying direct and indirect effects, the analysis shows how intra- and inter-institutional linkages produce increasing returns in institutional performance during water sector reforms. In the same line, Jellema and Roland (2011) perform a multi-factorial analysis of institutions to give evidence of the significant impact of institutional clusters on economic performance. We argue that mis-complementarities generate TTCs, reducing the coherence of a regime. Taking stock from Aoki's (2001, 2007) institutional games, TTCs can occur within the same domain (a given use) as well as, more probably, among domains (different uses); for instance ecological flow and hydroelectricity.

<sup>6</sup> In his initial demonstration, relying on supermodular games, Aoki supposes that the two studied domains do not interact directly: agents act only in one domain, technology and natural environment are constant (Aoki, 2001). More recently, he develops these ideas in a strategic game of actors, where each actor chooses institutions to maximize his utility regarding expected complementarities (Aoki, 2007).

The TTC concept expands the Transaction Costs perspective in public policy analysis to include external coherence. TTCs are not about interpolicy coordination issue but rather about coordination among two juridical corpus: public law, i.e., the formal enactment of public policies, and private law, i.e. the contractual form of property rights. This coordination reveals to be juridically, economically and politically complex (Varone and Nahrath, 2014). In addition, TTCs conceive institutional complementarity as a gradual feature, allowing for an accurate delineating of non- or partially complementary interactions among public policies and property rights.

We consider that the nature of TTCs can be *institutional*, *technological* or *organizational*. The *institutional* nature refers to property rights incompleteness and norms imperfection (Coase, 1960). Overly complex regimes due to the (autonomous) multiplication of bilateral or top-down norms make the institutional network more and more polycentric and unclear (Adam et al., 2018; Lubell et al., 2014). It favors the increase of TTCs. The *technological* nature is decisive, particularly in network industries (Fuenfschilling and Truffer, 2014; Künneke et al., 2010). Recent trends toward deconcentration and devolution of public command, as well as the setting of micro-institutions to create coherence, illustrate the *organizational* nature of TTCs (Saleth and Dinar, 2008). The scope of TTCs can be *specific*, i.e., related to micro components like contractual provisions, or *generic*, i.e., related to macro components like market regulation (Bolognesi, 2014; Williamson, 2000).

### 2.4. Implications of transversal transactions costs on integration in the long run

Public policies and property rights interact generating TTCs, which reduce the ability of each regime components to coordinate. At the beginning our focus was on the micro level, i.e., on discrete public policies and property rights. We now explore the implications of TTCs on the regime and its current ability to regulate natural resource uses in the long run. This up-scaling allows the distinction of the marginal impact of institutions from their aggregated effect (Garrick et al., 2013). TTCs are the result of extent increase and affect the external coherence of a regime, which in return affects the integration of an IRR (Bolognesi, 2014; Gerber et al., 2009). We thus explore the impact of extent evolution on regime integration. We assume that TTCs shape this relationship; therefore, we put forward that, in the long run, the increase of extent contributes to the increase of integration. However, the marginal impact of extent on integration is decreasing because of TTCs (Hypothesis 2).

We rely on institutional theory to argue that the impact of TCs on regime integration in the long run is negligible in comparison to the impact of TTCs. Two main drivers cause a stabilization of TCs impact overtime, a Darwinist process (Hodgson and Knudsen, 2010) and a trial-error process (North, 2005; Ostrom, 1992, 2005). The Darwinist process states that competition among institutions operates through a selection process maintaining the most efficient and legitimate institutions. The trial-errors process consists of actors refining institutions over time to enhance institutional efficiency, notably by making institutions more appropriate with local contingencies. These two processes contribute to an increase in the overall coherence of the regime, and reinforce the positive impact of extension on integration. But, when the regime starts having numerous and significant institutional interactions, TTCs become significant and a strong counterpoint to the decrease of TCs.

TTCs increase as there are more and more institutions, and they affect the dynamic of a resource regime. On the one hand, as literature shows, increasing extent<sup>7</sup> positively impacts integration by closing

<sup>7</sup> The regime extent increases when additional uses are regulated. Usually, scholars observe it through the enactment of new public policies or new

governance gaps. On the other hand, a negative and non-expected impact occurs because of external inconsistencies across institutions. TTCs affect regime coherence in two ways. Firstly, as the pool of different public policies and property rights enlarges, the number of institutional interlinkages logically also does so. TTCs thus become more abundant. This mechanism is similar to the idea of aggregated TCs (Garrick et al., 2013). Secondly, governance becomes more specialized, which makes the broader picture appears hard to grasp. As a consequence, some radical limitations and contradictions are more likely to occur within these new interactions. TTCs should then be more intense.

We assume that the negative effect of TTCs reinforces itself as the extent of the regime increases. It means that from a certain threshold, let's say  $r = z^*$ , additional extent produces more and more external incoherencies. In the long run, we hypothesize that the negative effect of TTCs offsets the positive impact of extent. We name this long-term implication of TTCs an Institutional Complexity Trap (ICT) to emphasize that regime refinements could primarily lead to more complexity but not to integration.<sup>8</sup> High degree of extent goes hand in hand with numerous and unpredictable interactions between public policies and property rights, which dramatically increases TTCs and constrains integration of the resource regime. We thus assume that:

**Hypothesis 2:.** In the long run, transversal transaction costs (TTCs) lead institutional resource regime (IRR) to an institutional complexity trap (ICT), meaning that the marginal impact of extent on integration is decreasing because of TTCs.

### 3. Micro dynamics: regime extent causes transversal transaction costs

#### 3.1. Identifying transversal transaction costs

Hypothesis 1 assumes the existence of TTCs, and that the latter are related to the interactions between public policies and property rights (Fig. 4). To grasp these interactions, we use the notion of regulation modes. Regulation modes identify four types of interactions between public policies and property rights (Gerber et al., 2009; Knoepfel et al., 2007), and thus allows the characterization of the extension process (Bolognesi, 2014; Renou and Bolognesi, 2019).

Regulation modes 1 and 2 are public pIn the long run, transversal transaction costs (TTCs) lead institutional resource regime (IRR) to an institutional complexity trap (ICT), meaning that the marginal impact of extent on integration is decreasing because of TTCs.olicies with respectively no direct impact (e.g., informational and incentive instruments like information campaigns, subsidies or taxes) and direct impacts on the content of property rights (e.g., emissions limitations, standards, quotas, or conditions of use). Regulation modes 3 and 4 set up property rights structures by respectively re-defining the content of property rights as an institution or changing property rights' allocation. An example in the case of the former is the introduction of State guarantee of private property in the Constitution, legal recognition of material expropriation or introduction of condominium property in the Civil code. In the case of the latter, this occurs, for instance, through privatization or nationalization.<sup>9</sup>

We use a conservative identification strategy to demonstrate that TTCs exist. Indeed, a broad understanding of TTCs should lead to

(footnote continued)

property rights, e.g., the signing of new contracts.

<sup>8</sup> In terms of practical implications, the ICT phenomenon suggests that refining governance is no more efficient when regime are complex. There is a need for transforming the regime as argued by Renou and Bolognesi (2019).

<sup>9</sup> One of the most challenging issues for policy makers is the creation or maintaining of coherence between public law regulations (modes 1 and/or 2) and private law regulations (modes 3 and/or 4) (Aubin and Varone, 2013; Bolognesi and Pflieger, 2019).

consider that each regulation mode creates TTCs given that regulation modes define the impact of public policy on property rights. But this identification corresponds to what regulation is made for: an adjustment through public policies of private behaviors and property rights incompleteness (Brousseau, 2008; Coase, 1960). Consequently, we focus only on the interactions occurring between regulation modes in order to avoid misconceiving regulatory adjustments as TTCs. The interactions between regulation modes are particularly complex in a regime design, and thus favor explaining how TTCs are likely to come up. In practice, it means that we focus on disturbances among different mechanisms of regulations. We consider these disturbances are not expected by policy-makers or private stakeholders, which reveal the very essence of the concept of TTCs. On one hand, this empirical strategy underestimates TTCs, but on the other hand, it strengthens the reliability of TTCs existence and thus the robustness of accepting hypothesis 1. Further, the underestimation is not an issue as long as we seek to demonstrate that TTCs exist, but do not intend to measure them.

Table 1 presents the interactions between different regulation modes which are of interest to us. We evacuated two of six conceivable interactions, namely modes 2-1 and modes 4-3 because they are unrealistic. We then explore four different case studies to illustrate and give an empirical ground to TTCs. The four cases have been selected within the IRR literature for the sake of consistency and to facilitate regulation modes observation. They address land use planning in Switzerland (Varone and Nahrath, 2014; Viallon, 2017) and water management in France (Bolognesi, 2018; Renou, 2017).

#### 3.2. Evidences from micro-dynamics: four illustrations of TTCs among regulation modes

This section presents four empirical examples of TTCs to ground our conceptual proposition.<sup>10</sup> A first and widespread case of TTCs consists in the interaction between **regulation modes 2 and 3**. In that case, TTCs emerge from the redefinition and/or limitation of the scope of property and use rights by (new) policy instruments over time which can create contradictions between the two components of the IRR. A typical example is the contradiction between land use planning policy and land ownership guarantees in Switzerland (Varone and Nahrath, 2014). The source of this contradiction is to be found in the new spatial planning regime established in 1969. This new federal regime is based on the attribution of responsibilities in the domain of land use planning to the federal state,<sup>11</sup> as well as on the constitutional guarantee of ownership and the principle of compensation in the case of significant restriction of use rights, called the "material expropriation" principle. These changes correspond to a double extension of the regime: through the federal land use planning act (public policies) and through the ownership guarantee and material expropriation principles (property rights). But surprisingly, this new regime didn't provide municipalities with any policy instrument (e.g., appreciation tax or tax on the increase of land value) allowing them to finance these material expropriations.

This fundamental contradiction between ownership guarantees (regulation mode 3) and local planning (regulation mode 2) increased TTCs dramatically because it hampered the capacity of municipalities to implement local planning in a coherent and restrictive way. Indeed, restrictive zoning entails significant restrictions of use rights, which in turn often leads to a material expropriation and financial compensation to be paid to the landowners by the municipality. Most of the time, the municipality does not dispose of the financial resources due to the absence of appreciation of the tax on the added value of land. This situation has led to a significant judicialization of land use planning

<sup>10</sup> We use these four cases for illustrative purpose. They are examples of how TTCs could look like.

<sup>11</sup> These responsibilities being legally established in the Federal Act on Land Use Planning of 1979.

**Table 1**  
Identification of TTCs: Cases selection of interactions between regulation modes.

	Mode 1	Mode 2	Mode 3	Mode 4
Mode 1	.	Unlikely	Land (CH)	Water (Fr)
Mode 2		.	Land (CH)	Water (Fr)
Mode 3			.	Unlikely
Mode 4				.

implementation (Rothmayr, 2001), contributing to a significant increase of TTCs and a relative blockage of the integration of the regime (Nahrath, 2003).

One can consider the regime to be in an ICT because this contradiction has yet to be solved. Currently, the definition of material expropriation still depends on the case law of the Federal Court, which generates a lot of inefficiencies in the coordination. In this case, TTCs are mostly institutional and generic. Land use planning policy in Switzerland creates TTCs by being misaligned with ownership guarantees. Therefore, restrictive zoning conflicts with the financial protection of property rights, revealing the institutional nature of these TTCs.

The second case refers to TTCs between **regulation modes 1 and 3**. In this case, we highlight the negative impacts that various kinds of environmental taxes can have on land value and on the costs of using existing use rights.<sup>12</sup> The impact on owners' use rights of an uncoordinated creation of federal and cantonal land and equipment taxes in the Canton of Vaud (Switzerland) provides a good example of the effects of a regime extension on TTCs (Viallon, 2017). In 2011, the Canton of Vaud introduced a tax on community facilities<sup>13</sup> aiming at capturing a part of private land added values resulting from public land use measures, in order to finance community equipment (public transports, schools, hospitals, public spaces and parks, nurseries, etc.). In 2014, the federal government introduced another tax on the value added to land by the zoning process (in an attempt to fund material expropriations and solve the contradiction we mentioned in scenario 1), which led to a public contestation denouncing a “double taxation”. Likewise, the Canton protests because he fears an induced lowering of its own tax. Institutional and generic dimensions are particularly present in this case too. The absence of consistent perspectives on incentives between the different levels of the resource regime (i.e., the contradiction between the federal and cantonal tax systems) creates TTCs.

The third case, which is the modernization of urban water governance in the European Union, exemplifies TTCs between **regulation modes 2 and 4**. This modernization process consists mainly of liberalizing and re-regulating the sector (Bolognesi, 2018). It increases the extent of the regime through regulation mode 2 such as the directive on the award of concession contracts (2014/23/UE) or the Directive on public procurement in network industries (204/25/EU). In consequence, private participation in the sector increased, mainly through PPP and corporatization. This school case emphasizes how measures on property rights allocation processes (mode 2) interact with property rights owners' identities (mode 4). In France, one of the most symptomatic resulting TTCs is the multiplication of new contractual forms and hybrid legal entities whose implications regarding incentives, responsibilities, and duties are still unclear. For instance, the “Société Publique Locale” form permits public owned entities to not comply with competition laws. These TTCs are to a large extent related to

organizational and institutional issues and they limit the coherence of the regime because they create numerous and intricate management configurations.

The fourth case refers to the TTCs between **regulation modes 1 and 4** and takes examples from the modernization of urban water governance. This reform stands on New Public Management principles and benchmarking instruments (mode 1) (Barone et al., 2018; Bolognesi, 2018; Renou, 2017). Following this trend, 17 performance indicators were put in place in France in 2007 under the supervision of a regulatory agency. The Water law of 2006 initiated this extent increase.<sup>14</sup> This organizational change conflicts with the current allocation of property rights (mode 4), creating TTCs. The new regulation mode 1 necessitates organizational changes in property rights structure. Indeed, in certain cases local actors are not organized in a way that is compatible with these performance reporting requirements. In addition, the new required organizational form is misaligned with the institutional environment of numerous services, especially regarding culture and routines. It generates resistances to the implementation and opportunistic behaviors like disclosure biases that reduce the efficiency of the coordination (Bolognesi and Pflieger 2019b). As a consequence, the extension of the French water governance system creates TTCs preventing its integration.

#### 4. Macro failures: transversal transaction costs cause institutional complexity traps

##### 4.1. Identifying institutional complexity traps

Hypothesis 2 assumes that TTCs lead to an Institutional Complexity Trap in the long run. In order to understand the dynamic impact of TTCs, i.e., ICT formation, we focus on the evolution of extent and integration of resource regimes in the long run. Integration and extent are broad institutional features which cannot be objectively measured (Voigt, 2013). To make the measure as reliable as possible, we rely on assessments of extent and integration provided by resource regime experts. We selected comparable assessments that stand on a common methodology. While these two conditions prevent us from collecting a large-N sample, they allow for an accurate identification of the effect of interest. We carry-out a small-N process-tracing analysis to find evidence of ICT (Collier, 2011; Trampusch and Palier, 2016), paving the way for potential future empirical investigations testing each specific mechanism.

The required empirical materials comes from the EUWARENESS research project (Kissling-Näf and Kuks, 2004; Kuks, 2004).<sup>15</sup> Our method to observe ICT transforms the EUWARENESS qualitative assessments of European water regimes into quantitative ordinal variables. Kissling-Näf and Kuks (2004) and (Kuks, 2004) synthesize into tables the qualitative assessments resulting from the EUWARENESS project. We have recoded these tables to build our dataset. Then, we are, enabling us to compare the evolution of extent and integration in the long run.

EUWARENESS analyzed the evolution of water regimes in the Netherlands, France, Belgium, Switzerland, Italy, and Spain from their emergence in the mid-late eighteenth century until recent times. The time span of the dataset goes from 1750 to 2004. Contributors have identified five to six phases in the evolution of each national water regime (Table 2). A common methodology delimits the sources and criteria that must be implemented to assess extent and integration

<sup>12</sup> e.g., infrastructure or equipment tax, waste water tax, tax on land added value, soil decontamination tax, Transferable Development Rights (TDR) or CO<sub>2</sub> tax.

<sup>13</sup> Articles 4b and sqs of the cantonal law on communal taxes of December 5th, 1956 (RSV 650.11).

<sup>14</sup> The full name of the law is “Loi sur l'Eau et les Milieux Aquatiques”, which means “Law on water and water areas”.

<sup>15</sup> EUWARENESS means “European Water Regimes and the Notion of a Sustainable Status”. It is a FP-5 project funded by the European Commission. Methodology and results could be accessed from <http://www.euwareness.nl/home/>.

**Table 2**  
National water regimes evolution main phases.

Country	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6
Netherlands	1814–1890	1890–1954	1954–1969	1969–1985	1985–1995	1995–2004
Belgium	1804–1893	1893–1945	1945–1980	1980–1995	1995–2004	
France	1789–1898	1898–1945	1945–1964	1964–1992	1992–2004	
Spain	1866–1898	1898–1959	1959–1978	1978–1985	1985–2004	
Italy	1865–1933	1933–1976	1976–1989	1989–1999	1999–2004	
Switzerland	1870–1953	1953–1975	1975–1991	1991–1997	1997–2004	

within each regime. After the analytical phase, project leaders proceeded to a cross-validation among the case studies to ensure their reliability and consistency. Furthermore, these cases are well-studied in the literature which permits appraising the robustness of the EUWARENESS project, and thus the reliability of our empirical materials.<sup>16</sup>

The qualitative assessments of extent and integration carried-out in EUWARENESS follow a classification spanning from “Non-existent “ to “Integrated” regarding integration, and “No“ to “Full” regarding Extent. For each identified phase, we score linearly these assessments from 0 to 10 (Table 3). We choose a linear score scheme with a ladder of equal scales to favor the identification of non-linearity and facilitate interpretation.<sup>17</sup> It provides a unique sample about integration and extent that allows for a direct analysis of these two characteristics without any reference to historical dynamics. Indeed, existing studies of environmental governance evolution are based on historical screening, and extent and integration could not be reflected on without considering the temporal aspect. The dataset combines 31 pairs of extent and integration; i.e., five stages of extent and integration for each country, except in the Netherlands (6 stages).

This mixed research design (Creswell, 2014) allows to generate data on under-investigated institutional characteristics in the long run, extent and integration in this case (Bolognesi and Pflieger, 2019; Trein et al., 2018). Qualitative assessments grasp these characteristics, but prevent the extraction of extent and integration from their historical context. Coding the qualitative material offers a successful way to overcome this difficulty, and to observe the direct link between extent and integration (Collier, 2011). The combination of qualitative assessment and quantitative coding provides a unique dataset on the institutional mechanisms of change, and especially the evolution of extent and integration of environmental governance over two centuries in the scope of this research.

4.2. Macro level incidences of TTCs in the long run: theory for ICTs

We argue that TTCs evolve differently from TCs, shaping the non-linear impact of the extent on the integration. The pathway of the regime integration process, in the long run, goes through three phases: a start, a development and an ICT (Table 4). In the start phase, the extent has no significant impact on integration because TCs are high, limiting the coherence of each of the few public policies and property rights that compound the regime. Consequently, integration remains low, while

<sup>16</sup> Among others for: the Netherlands (Kuks, 2004), France (Bolognesi, 2018), Belgium (Aubin and Varone, 2001), Switzerland (Varone et al., 2002) and Spain (Swyngedouw, 2014).

<sup>17</sup> See the “Data For” file to access the Code for scoring cases. We do not code for the coherence for three reasons. First, the paper deals with the link between extent and integration, TTCs and external coherence are intermediate variables in the test (see Fig. 1). Second, theoretically, we put forward the role of external coherence that is not properly assessed in EUWARENESS. EUWARENESS assessments of coherence follows three categories (low, medium, high), which limits the ability to identify non-linearities as we intend to do. Overall, it does not prevent us from testing Hypothesis 2, which assumes that TTCs link extent to integration - even if we theoretically argue that the non-linearity is due to coherence changes.

**Table 3**  
Coding of integration and extent from qualitative assessments.

Quantitative score	Qualitative assessment of integration	Extent
0	Non-existent	No
1.25	Low simple	
2.5	Simple	Low
3.75	High simple	
5		Average
6.25	Low complexity	
7.5	Complexity	High
8.75	High complexity	
10	Integrated	Full

extent increases. In the development phase, the regime is made of more public policies and property rights, and TCs stabilize at low levels because the Darwinist and trial-error processes had time to manifest. Actors have adapted institutions to their context. On the other hand, TTCs appear, grow but keep capped at low levels. This is the main phase of evolution of the regime, with the extent as the main driver of the integration increase. In the ICT phase, the number of public policies and property rights is extremely high. In comparison to the development phase, TTCs continue to multiply exponentially preventing any positive impact of the extent on integration. Integration is capped and cannot increase anymore because the external coherence of the regime is deteriorating. The regime falls into an institutional complexity trap.

The way TTCs evolve in the long run is critical to understand how they lead to an ICT. TTCs can increase through two distinct channels, volume and intensity. The first channel is the growth in volume of institutional overlaps and interplays, i.e.,  $(PP_{j,i} \cap PR_{j,i})$  in Eq. (2). The global amount of TTCs increases because there is more room for them. The second channel refers to the quality of interlinkages, i.e.,  $\sigma$  in Eq. (2). Interlinkages are more and more complex and have indirect effects that are difficult to anticipate for they exacerbate the incompleteness of institutions as well as the impact of bounded rationality. Each new institutional incoherency may become stronger. The global amount of TTCs increases because of their intensity.

To assess the likelihood of these dynamics, we synthesize the evolving impact of extent on integration as follows. The relation corresponds to a sigmoidal function of integration (Fig. 5). In the start phase, the curve is low and flat, then it significantly increases during the development phase. In the ICT phase, the curve flattens because of the increase of TTCs. The regime  $i$  regulates different uses of the resource  $j$  through institutions,  $r$ . For most  $r$ , institutions of different uses are independently designed. We argue integration ( $I$ ) theoretically is a sigmoidal function of extent (blue curve in Fig. 5):

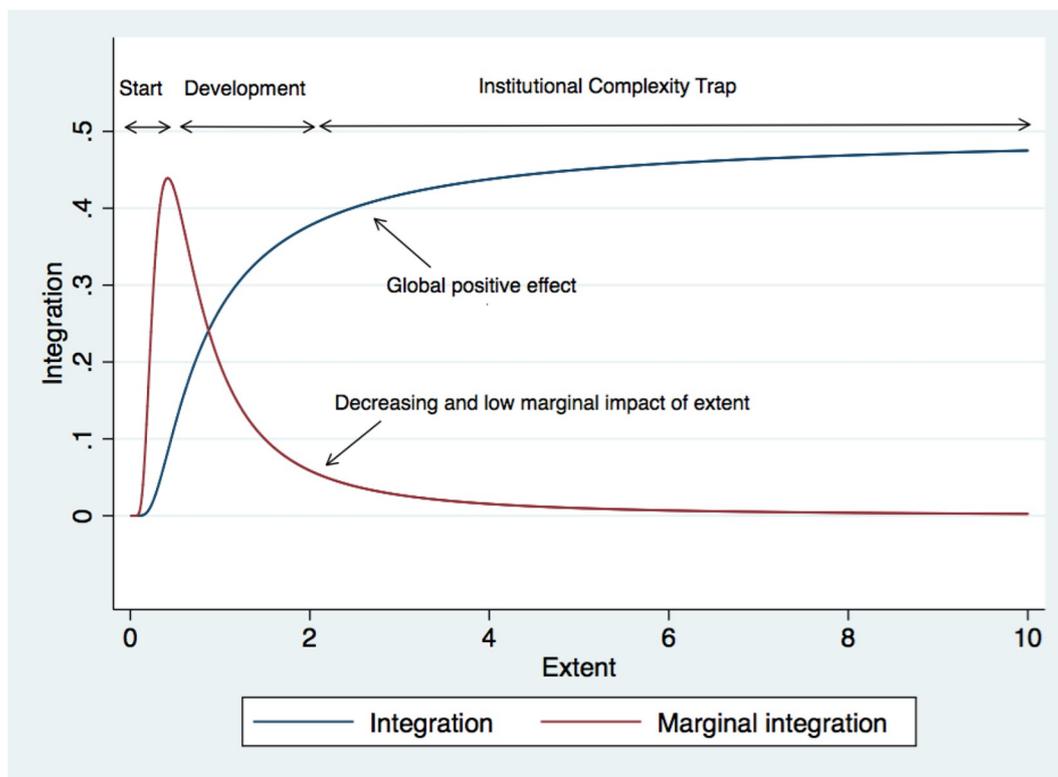
$$I_{i,j} = \frac{1}{1 + e^{\frac{1}{r}}} \tag{3}$$

Consequently, the marginal impact of extent on integration,  $I'$ , is (red curve in Fig. 5):

$$I'_{i,j} = \frac{e^{\frac{1}{r}}}{r^2 (e^{\frac{1}{r}} + 1)^2} \tag{4}$$

**Table 4**  
Evolution of TCs and TTCs according to the phases of the regime evolution.

Phase	TCs	TTCs	Positive impact of extent on integration	Integration
Start	High and ↘	None	Low	Low
Development	Stable	Low and ↗	High	Strong ↗
ICT	Stable	High and ↗	Null	Capped



**Fig. 5.** Regime integration process and the Institutional Complexity Trap. By construction, the “Institutional Complexity Trap” occupies most the figure. It is important to keep in mind that the x-axis doesn’t reflect the time in the historical pattern of environmental governance but the level of extent. A historical perspective would leave more space to the “start” and “development” phases. The “start”, “development” and ‘Institutional Complexity Trap’ phases respectively correspond to phases 1, 2 and 3 in the main text. (For interpretation of the references to color in this figure, the reader is referred to the web version of this article.)

The limit of the marginal impact of extent on integration as extent approaches infinity is 0.<sup>18</sup> This characteristic locks the resource regimes in an institutional complexity trap. In other words, if  $I_{i,t}$  is concave and  $\lim_{r \rightarrow \infty} I'_{i,t} = 0$ , then the resource regime dynamics tends to an ICT.

**4.3. Evidences from long-term macro-dynamics: path to ICTs**

We converted the EUWARENESS project case studies on European water regimes into quantitative data to enable a systematic comparison of the evolution of extent and integration in these regimes since the 18th century.<sup>19</sup> The literature confirms that, in these cases, extent increases involved interactions between public policies and property rights (Appendix B provides the evidence). It ensures that the cases

<sup>18</sup> The threshold from which the marginal impact of extent on integration turns to decrease is  $r^*$ , where  $I''(r) = 0$ .

<sup>19</sup> Figs. 6, 7, and 8 present the evolution of regimes with a smoothed view for the sake of readability and coherence with regard to our proposition. Raw data is represented with stepped curves which do not correspond to reality. Institutional dynamics are mainly incremental, meaning that extent and integration perpetually evolve. By smoothing the trends of these institutional features, we aim at emphasizing the idea that institutional change is a continuous process (North, 2005; Roland, 2004). Grey areas represent the uncertainty of adjustment.

offer a proper identification of the mechanisms we test for through the hypothesis 2. We first describe the evolution of integration and extent. Then, we compare the evolution of extent and integration to assess consistency with our proposition of a decreasing marginal impact of extent on integration.

Water governance in European countries stood on the delineation between public and private waters during the end of the 19<sup>th</sup> century (Kissling-Näf and Kuks, 2004; Varone et al., 2002). At that time, public policies addressed governance gaps by refining the definition of property rights and entering new uses into the domain of the regime. The main areas of concern were health, agriculture, urban water, and hydroelectricity. Lately ( 1970–1980), environmental concerns have been integrated into the exercise of governance, notably the polluter pays principle, as well as integrated water resource management principles. Integration of water regimes in Europe was not significantly enhanced until the 1980s as a consequence of inconsistencies between the different public policies and property rights (Bolognesi, 2014, 2018). Furthermore, the low quality of water bodies, as well as the lack of investment in water utilities, suggests that significant failures remain in the European water regimes.

In the long run, we observe an increase in the integration of European water regimes as a general trend (Fig. 6). The comparison of the six national water regimes brings to light three pathways of regime integration. Dutch regime integration appeared to be regular from its

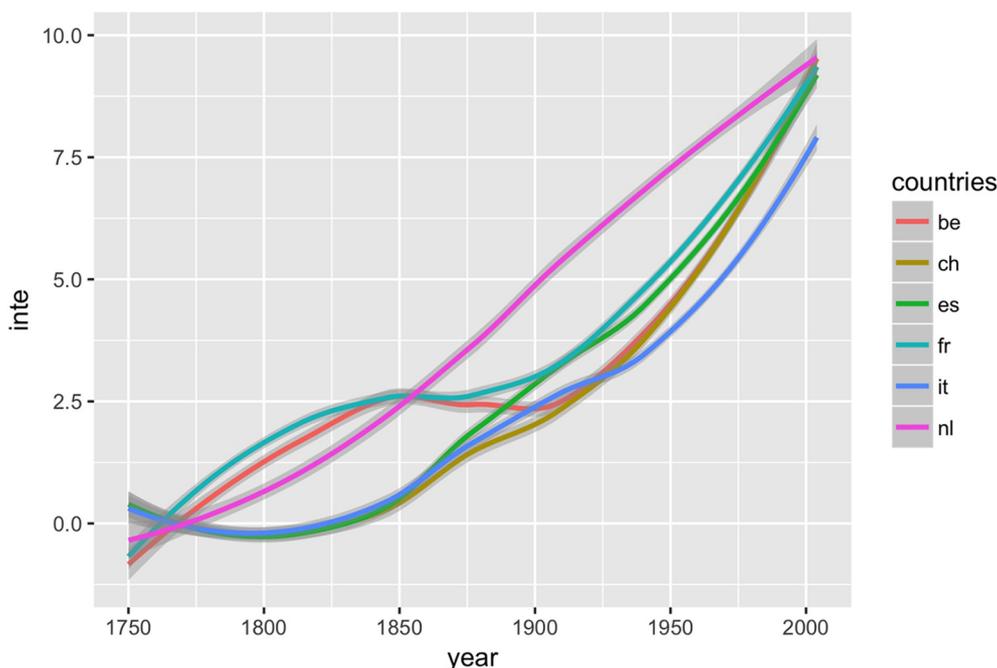


Fig. 6. Evolution of the integration of six European water regimes from 1750 to 2004.

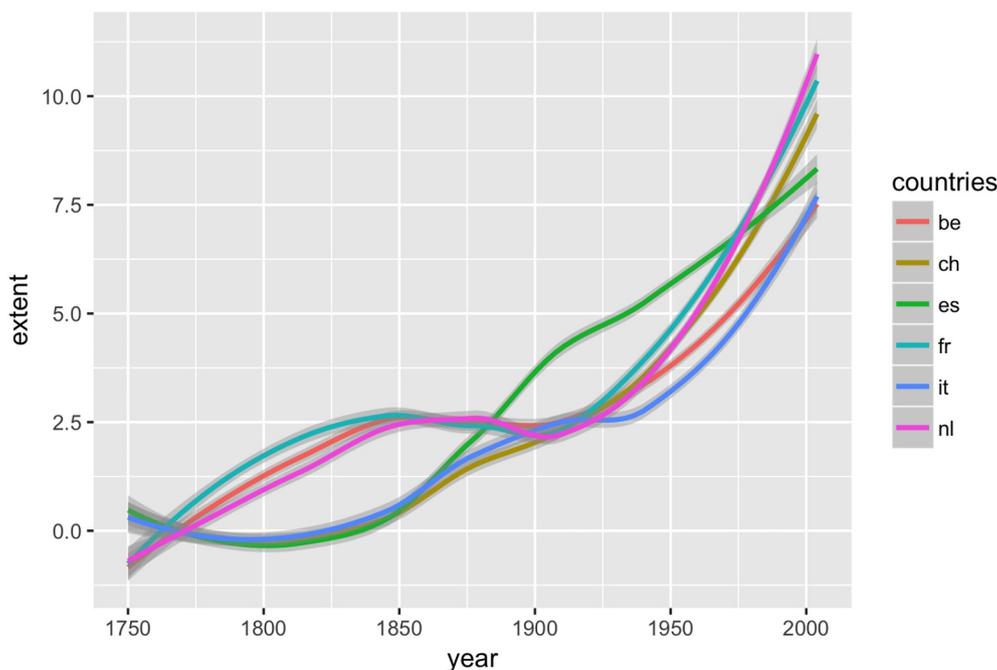


Fig. 7. Evolution of extent in main European water regimes since 1750.

beginning in the 18th century to nowadays. Italian, Spanish and Swiss regimes evolved by pursuing a second pathway that is a regular integration since the middle of 19th century. French and Belgian regimes followed a third pathway. They started integrating in the middle of the 18th century. The process, however, was marked by a pause in the early 19th century, to finally restart and converge with the second pathway (Italy, Spain, and Switzerland).

Extent dynamics are different (Fig. 7). In each regime, we observe three phases: increase, pause, strong increase (stronger than the first phase). Generally, the first phase of increase is property rights driven, while the third phase of strong increase is mainly policy driven (Kissling-Näf and Kuks, 2004). The paces present in the different phases delineate three pathways. French, Belgian and Dutch regimes started

extending earlier than others. Their first phase corresponds to a relatively slow increase of extent, and then to a longer pause. In their third phase, extent escalates more than in the other regimes. Swiss and Italian regimes draw a second pathway. They started extending in the middle of the 19th century, marked a short pause, and started extending again. Spain followed its own extent pathway, which started in the middle of the 19th century and pursued a regular increase until nowadays. It proves to be a singular pathway as there is no clear pause, rather a slowing of extent increase and the third phase is not stronger than the first one.

We now focus on the interlinkage between extent and integration. Fig. 8 shows that the relationship between extent and integration is not linear in the long run. Inflections are due to (in)coherencies. The

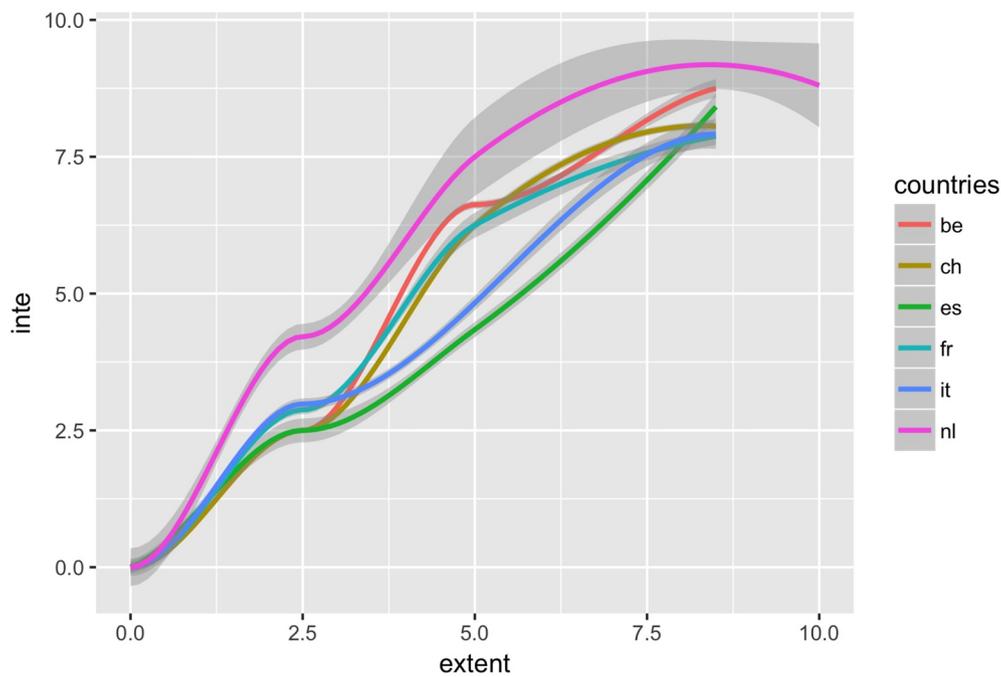


Fig. 8. Impact of extent on integration in the main European water regimes.

steeper the yield curve, the stronger the link between extension and integration and thus the higher the coherence. Globally, results indicate that during their first phases, i.e. phase 1 “start” and phase 2 “development” in the theoretical prediction (Table 4 and Fig. 5), regimes were coherent. Then, during the third phase (“Institutional Complexity Trap”) overlaps and interplays appeared. They mark a tipping-point from which coherence reduced, and TTCs became significant and increasing. We observed that the slope of the relationship between extent and integration flattens, characterizing an ICT.

Three observations confirm our second hypothesis (Fig. 8). Firstly, the relationship between extent and integration is monotonous and positive. Secondly, the relation is not linear. It is in line with the theories arguing that a Darwinian and trial-error learning processes contribute to craft institutions (Hodgson and Knudsen, 2010; Ostrom, 2005). Besides, in these adaptation processes, it is obvious that curves tend to flatten as extent continues to increase. This third observation confirms our second hypothesis. Starting from a threshold, where institutions are numerous, the marginal impact of extent on integration decreases. Moreover, the older regimes (Dutch and French ones) seem to have reached a stage where the marginal integration is almost null. This suggests that they have entered into an ICT. The observed shape of the integration pathway supports the hypothesis that TTCs affect negatively the integration process after the development phase of the regime (Fig. 5).<sup>20</sup> When extent reaches high levels, integration processes dramatically slow down.

In sum, at low levels of extent, TTCs are low. Therefore, the evolution of TCs strongly determines the link between extent and integration. The search for coherence leads to reducing TCs. As TTCs grow, they produce a curve inflection at high levels of extent (Fig. 8). This offers evidence for the role of TTCs and supports the existence of the ICT: highly developed environmental governance regimes face accelerated difficulties to become more integrated. It is noticeable that none of the six studied regimes reached a fully integrated form (Kissling-Näf and Kuks, 2004).

<sup>20</sup> Low level of integration corresponds to a short stagnation in the extent process. It corresponds to our theoretical expectation, but it is worth noticing that it is partly due to our methodology which smoothes the curves, assuming that evolution is continuous not stepped.

## 5. Discussion

This article proposes a new theoretical answer to the question of environmental governance failures, combining micro and macro explanations in the long run. We put forward the concept of Transversal Transaction Costs (TTCs) and derived from its long-term implications at the macro level the concept of Institutional Complexity Trap (ICT). We demonstrate how TTCs emerge from interactions between public policies and property rights, limiting the coherence of an Institutional Resource Regime (IRR). Drawing on institutional complementarities and clusters literature, we emphasize that TTCs are consequential in limiting the ability of environmental governance to coordinate natural resource uses. TTCs significantly increased over the years, shaping institutional change and leading regimes to end up locked into an Institutional Complexity Trap (ICT). The latter prevents integration, i.e. improvement in coordination capacity, and contribute to explaining the persistence of environmental governance failures despite the refinements of the regimes.

We use four empirical examples (Section 3) are used to show how interlinkages between public policies and property rights might be in contradiction at the micro-level, inducing TTCs. These transaction costs are transversal because they are related to unexpected interlinkages between the two main components of a regime (public policies and property rights). We show that the “transversality” of this type of TCs makes them much more consequential and difficult to identify. The contradictions between the two different foundation stones of environmental governance imply complex and costly (re)alignments (Oberthür and Stokke, 2011), at least in civil code regimes (additional research should indeed be conducted in the case of common law countries).

To show the macro implications of TTCs in the long run, we analyze the evolution of six European water governance regimes, from 1750 until 2004 (Section 4). The analyses provide an empirical evidence supporting the second theoretical hypothesis (a decreasing marginal impact of extent on integration because of TTCs). Indeed, we observed an exponential increase of public policies and property rights in the long run while integration processes slowed down over the past decades. Integration evolution was thus not linear, for it followed three phases: 1/ a “start” with a weak increase 2/ a “development” with a

strong increase 3/ an “ICT” with a very-weak increase or a slight decrease (Fig. 8). The observed evolutions show the sequences of changes in environmental governance: the relation between extent and integration across time has known a tipping-point, highlighting the emergence of an ICT.

The paper offers some methodological lessons too, in particular regarding mixed research designs (Creswell, 2014) and the operationalisation of process-tracing analysis (Collier, 2011; Trampusch and Palier, 2016). We focus on institutional characteristics that are hard to specify and measure (Voigt, 2013). The use of qualitative assessments allows us to grasp these characteristics, but qualitative analysis prevents us from extracting extent and integration from their historical anchorage and thus to a direct structural link. Coding the qualitative material offers a successful way to overcome this difficulty. The combination of qualitative assessment and quantitative coding provides a unique dataset on the evolution of extent and integration of environmental governance over two centuries, highlighting the mechanisms of institutional change.

The identification of TTCs and ICT has three main practical implications for environmental governance. First, contradictory overlaps and interplays between public policies and property rights are the most significant limitations to integration in already developed governance designs. It argues in favor of structural change of the resource regime rather than a perpetual search for refinements of the same the resource regime (Renou and Bolognesi, 2019). Second, conversely, static and dynamic TCs are critical in the first phases of governance development. During these phases, attention should be paid to the coherence of each public policy and property right. Third, it appears that in developing governance design (phase 2) the increase of the scope of regulated uses is an essential source of integration. It probably relates to a global effect of transformation from weak to strong institutional environment (Ostrom, 2005).

Finally, as a theoretical consequence, the concept of TTCs emphasizes the crucial importance of analytically distinguishing between two different sources of law: private law (i.e., the legal definition of property rights) and public law (i.e., public policies) (Gerber et al., 2009). Such a distinction constitutes a crucial point as it allows to differentiate between two types of TCs, as well as to understand the specificities of TTCs. It concretely shows how “transversal” TCs between public policies and property rights are specific and differ from “internal” TCs (within the public or private law). Their transversality makes them more unpredictable and more challenging to solve. To our knowledge, such a distinction (as well as its consequences) are rarely taken seriously in the literature.

#### Declaration of Competing Interest

We have no conflict of interest regarding the research paper “Environmental Governance Dynamics: Some micro foundations of macro failures”.

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#### Appendix A. Interactions among institutions

The interactions among public policies and property rights remain under-investigated in the literature. However, we can classify institutional interactions with regard of their nature to position transversal transaction costs, i.e., interactions between public policies and property rights:

1. Adaptation of an institution to its context. This has already been identified as transformation (North, 1994) or transition TCs (Garrick

et al., 2013; Marshall, 2013);

2. Contracts and multilevel relations (Brousseau, 2008). These interactions relate to property rights only;
3. Interplays between different institutional regimes (Oberthür and Stokke, 2011). These interactions concern national regime of international domains of natural governance such as climate or ocean;
4. Interactions among public policies and property rights within a given resource regime (Gerber et al., 2009). They have received poor attention to our knowledge, and are subject to Transversal Transaction Costs.

#### Appendix B. Extent increases involves interactions between public policy and property rights: evidence from European water regimes

##### B.1. Theoretical rationale and underlying assumptions.

Standing on the Darwinist (Hodgson and Knudsen, 2010) and trial-error (Hassenforder and Barone, 2018; Ostrom, 1992) processes of institutional change, we could assume with a high degree of confidence that regime internal coherence should increase over the years. Garrick et al. (2013) provide an empirical evidence supporting this assumption. They show that even if the volume of the transaction costs increases over the years, as there are more and more institutions, the average level of transaction costs per institution remains stable or decrease. Consequently, non-linearities in between extent and integration could be attributed to external coherence and thus to TTCs. It supports our proposition that TTCs (a micro-mechanism) lead to an ICT (a macro-dynamic).

We prove that each institution is likely to generate TTCs because of the incompleteness and imperfection (Coase, 1960) of institutions and because of (non)complementarities (Amable, 2016). So, we could theoretically argue that extent involves interactions between public policies and property rights.

##### B.2. Empirical evidence from existing literature and the EUWARENESS project.

The literature addressing our six European water regimes cases provide empirical evidence that extent involved interactions among public policies and property rights (Aubin and Varone, 2001; Bolognesi, 2014, 2018; Kissling-Näf and Kuks, 2004; Kuks, 2004; Reynard et al., 2000; Varone et al., 2002). The literature that does not rely on the Institutional Resource Regime framework come to similar observations (Bakker, 2002, 2010; Buchs, 2014; Hassenforder and Barone, 2018; Swyngedouw, 2014; Thomann et al., 2016).

Case-studies carried-out during the EUWARENESS project and their final synthesis (Kissling-Näf and Kuks, 2004) demonstrate that public policies and property rights interact as extent increases. For instance, Aubin and Varone present the evolution of the Belgian water regime as “a combination of property rights and policy design” (Kissling-Näf and Kuks, 2004, p. 167). They highlight how some new public policies limits property rights, distinguishing formal ownership rights, disposition rights and use rights (Kissling-Näf and Kuks, 2004, p. 153, Table 5.2). Mauch and Reynard conclude that in Switzerland during the phase 1870–1912 “The external coherence of the regime was medium: with regard to protection against water, the target groups partly coincided with the owners of the surface waters (public bodies); in the field of water protection, the target groups (polluting industries) were not the owners of the resource” (Mauch and Reynard, 2004, p. 318). They observe the same dynamics about owners (property rights) and target group (public policy) during all the expansion of the regime. Linked to this, Aubin and Varone (2013) address how actors could game this interaction in order to maximize their access to water.

Bolognesi (2014, 2018) highlights interactions between public policies and property rights at the European level, along the regime

expands. He argues that the issues of public policies interaction with property rights is central to understand the failure of the water governance modernization — talking of “the paradox of the modernization”. “The main sources of inconsistency [ ... ] lie at the interface of policy design and the regulatory state”. A proxy of external coherence, i.e. cross coherence of public policy and property rights, is the number of disputes. Water disputes represented 20% of breaches to the European environmental legislation in 2010. Most recent evidence comes from Bolognesi and Pflieger (2019). They investigate the coherence of the water sector in Switzerland. They offer a new typology to allow an accurate measure of coherence types. They identify different forms of “extent related coherence” and find that it is where most of the lack of coherence is located. Further, they show that external coherence (i.e., coherence between public policies and property rights) is the major issue in the current Swiss water regime.

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