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# Particular requirements for institutional analysis in nature-related sectors

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## Summary

Agriculture, horticulture, fishery and forestry are nature-related sectors that interact frequently with natural systems. This interaction represents a source of enforcement problems and transaction costs in the context of governing transactions. Institutional analytical frameworks used in agricultural economics should consider the particular properties of transactions involving natural systems. For ordering nature-related transactions, we propose a heuristic framework based on two dimensions: 'modularity and decomposability of structures' and 'functional interdependence of processes'. It serves as a starting point for establishing a typology ranging from 'atomistic-isolated transactions' to 'complex-interconnected transactions'. The complex process of institutionalising such transactions is decomposed into conceptual categories by means of a 'transaction-interdependence cycle'.

**Keywords:** institutions, governance, natural-social systems interaction, nature-related transactions, typology

**JEL classification:** B52, D02, D23, Q10, H41

## 1. Introduction

Agricultural economists looking for a framework of institutional analysis applicable to their subject areas will find hardly any approach that explicitly focuses on the field covered by agricultural economics, with its heavy focus on interaction with natural systems[1] by means of agriculture, horticulture, fishery, forestry, resource management and nature conservation. At least two major schools in institutional analysis emphasise that biophysical and technical specificities matter. Transaction cost economics argues that the transaction, including its relevant physical dimension, 'is the basic unit of analysis …'. Williamson (1985: 18) and Ostrom (2005: 22) emphasised

1 The term 'natural systems' is used in this paper as a collective name for parts of the earth system such as ecological systems, biophysical systems, hydrological systems, geophysical systems, biological systems, atmospheric systems, etc. These systems have in common that they are not man-made although often used, modified or influenced by humans. For example, farmers do not have full control regarding natural fertility and vulnerability of soils, as various types of soil degradation show. Similarly, food products after processing and distribution still embody attributes characteristic of biological systems.

that the way rules impact upon actors' behaviour is 'also affected by attributes of the biophysical and material world being acted upon or transformed'.

As a consequence, we have to assume that the *physical world* (and the related physical properties of a transaction) is as important for institutional analysis as the *social world* (and the related physical characteristics of actors) and that both may substantially affect institutional change and institutional performance. This assumption may apply beyond those subject areas treated by agricultural economics and resource management (e.g. to tourism, which often depends on the beauty of landscapes). But the most frequent and most direct relationship to environmental resources such as soil, water, air, climate, plants and animals is found in the economic activities related to agriculture, horticulture, fishery, forestry, resource management and nature conservation.

Because such activities generate transactions with particular properties, the starting point of this paper is that this aspect should receive more emphasis when applying institutional analysis to those fields. The reason why the transaction is taken as the unit of analysis is that the properties of the transactions are strongly influenced by attributes that are typical of natural systems not designed by humans. This raises the question as to whether this requires the design of special institutions and governance structures suitable for regularising the interdependence between actors who are associated with those transactions.

The focus on the field of institutional analysis of particular interest for agriculture can be seen as a continuing tradition in the Congresses of the European Association of Agricultural Economists. At the 2005 Congress, Ménard and Valceschini (2005) dealt with 'New Institutions for Governing the Agri-food Industry'. At the 2002 Congress, Vatn (2002) discussed policy-specific transaction costs in his contribution on 'Multifunctional Agriculture: Some Consequences for International Trade Regimes'. Moreover, the specificity of nature-related transactions is relevant not only in selected research areas of agriculture, horticulture, forestry and fishery such as resource management or rural development, but also in many others (although to a different degree) including consumer food economics, supply chain management, agricultural trade and institutional change in transition countries (see Section 4.2).

This paper is organised as follows. Building on the Institutions-of-Sustainability Framework, the main concepts and terms used in later sections are explained in, particularly, a differentiated view of transactions that are taken as the main unit of analysis (Section 2). We then explore how conventional economics and transaction cost economics conceptualise the relevant properties of transactions and argue that an analytical distinction should be made between the basic attributes of physical entities, the properties of transactions influenced by them and the resulting demands on competencies of institutional and organisational arrangements for governing the transactions (Section 3). Another question is whether the need for regularising a transaction resides only in frictions in man-made, mostly engineered systems, as emphasised by transaction cost economics, or also in the interconnectedness

of natural systems not fully designed by humans. This motivates a brief review of nature-related institutional analytical frameworks, which shows that this point is recognised by only a few schools. Polycentricity of governance and diversity of hybrids (forms of organisation that could be responses to the complexity and interrelatedness of nature-related transactions) have received more attention (Section 4).

For ordering nature-related transactions in terms of their properties, we propose a heuristic framework defined according to two dimensions: modularity and decomposability of structures, and functional interdependence of processes. It provides the basis for a typology based on the continuum between atomistic-isolated transactions and complex-interconnected transactions as a frame of reference (Section 5). To understand the role of the specificities of nature-related transactions in interacting social and natural systems, our research strategy tackles complexity by applying procedures of conceptual decomposability (Section 6). This yields a set of conceptual categories, which correspond to stages of a 'transaction-interdependence cycle', for structuring the process leading from physical transactions to institutionalised transactions. We suggest applying the principle of discriminating alignment to the governance requirements deriving from the particular properties of nature-related transactions, in order to achieve a match with the institutions and governance structures to be developed (Section 7).

## 2. An analytical framework for investigating nature-related transactions

### 2.1. Conceptual categories of institutional analysis

The main analytical elements that need to be taken into account to arrive at an understanding of institutions have been assembled in the Institutions of Sustainability (IoS) Framework (Hagedorn *et al.*, 2002) which focuses on how to regularise human action that leads to transactions affecting the relationship between natural and social systems. The approach assumes that institutions (sets of rules) and governance structures that make them effective emerge either spontaneously through self-organisation or intentionally by human design. How these institutions and governance structures are socially constructed depends on the properties of the transactions and the characteristics of the actors involved in such transactions. Such processes take place in action arenas where actors are confronted in an action situation (Figure 1). Applying the IoS framework requires taking account of institutional and physical time lags (Thiel, 2006: 30).

The following statement by North reflects the prevailing understanding of *institutions* in economics and political science: 'Institutions are the rules of the game in a society or, more formally, are the humanly devised constraints that shape human interaction. They are made up of formal constraints (e.g., rules, laws, and constitutions), informal constraints (e.g., norms of behaviour, conventions, and self-imposed codes of conduct), and their enforcement

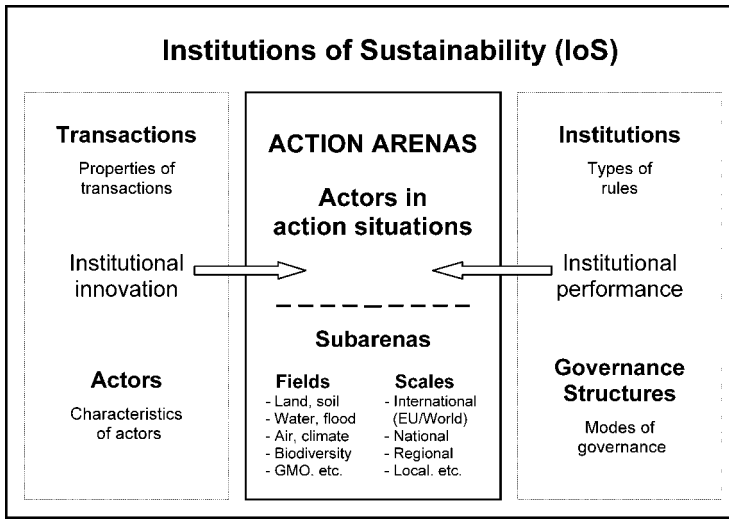


**Figure 1.** An analytical framework for institutional analysis.

characteristics. In consequence, they structure incentives in human exchange, whether political, social, or economic' (North, 1990: 3). Similarly, Ostrom (1990: 51) emphasised that '... an institution can be defined as the set of working rules that are used to determine who is eligible to make decisions in some arena, what actions are allowed or constrained, what aggregation rules will be used, what procedures must be followed, what information must or must not be provided, and what payoffs will be assigned to individuals dependent on their actions'.

*Governance structures* such as contracts, networks, bureaucracy, cooperation or markets are organisational solutions for making institutions effective, i.e. they are necessary for guaranteeing rights and duties and their use in coordinating transactions. Therefore, it is important to distinguish between *institutions* and *organisations* (Bromley, 1989: 43). The latter are not themselves institutions; rather they reveal how institutions define concrete governance structures for shaping human (inter)actions at an individual or collective level. Property rights are a subset of formal or informal institutions.

*Actors* find themselves in *action arenas* where '... participants and an action situation interact as they are affected by exogenous variables [...] and produce outcomes that in turn affect the participants and the action situation' (Ostrom, 2005: 13). An *action situation* occurs 'whenever two or more individuals are faced with a set of potential actions that jointly produce outcomes ...' (Ostrom, 2005: 32). Although not all *actions* are automatically associated with *transactions*, we are primarily interested in the latter because they present economically relevant processes by which goods and services, resources and amenities, and damages and nuisances are allocated. In a

densely populated world with almost no free goods left, we also must assume that these transactions cause *interdependence* between actors because they affect their opportunities to access goods or services, to use resources or amenities and to be protected against damages or nuisances in an either incompatible or synergistic way. As a consequence, actors will usually respond to the transaction, and this leads to *interaction* between the actors. Only humans who are able to *consciously select* what action they want to take can be called *actors.* Non-human entities, such as elements of a natural or technological system, may respond to human action if they are affected by them, but do not consciously make choices. In this respect, 'interaction' between social and physical systems, for example, 'human-ecosystem interaction' or 'human-transportation system interaction', is *different* from interaction between actors. Interaction between social and physical systems is internal to transactions and interaction between actors is external to transactions.

### 2.2. The transaction as unit of analysis

In this paper, we explicitly do not want to conflate the physical and the institutional dimensions of a transaction. This would assume that a transaction is already agreed upon at all levels including institutions and governance structures both for the public ordering (e.g. laws) and the private ordering (e.g. contacts) required and that the way in which these institutional and organisational arrangements apply in particular cases is already given. Instead of this 'ex-post institutional change perspective', we prefer an 'ex-ante institutional change perspective' where a physical transaction is planned or has already occurred, intentionally or unintentionally, without being institutionalised. We do this for analytical reasons. At the end, we will try to decompose the process into a series of stylised steps to illustrate how and why physical transactions become institutionalised transactions (see Section 7.1 and Figure 2).

Accordingly, we first consider a *transaction* in terms of its *physical* dimensions and those properties that are *physical* in nature (although their perception and interpretation are always socially constructed). This builds on the definition that prevails in transaction costs economics: 'A transaction occurs when a good or service is transferred across a technologically separable interface. One stage of activity terminates and another begins' (Williamson, 1985: 1). The focus on the economically relevant characteristics of a transaction may be too limited because it explains the need for a transaction to be governed by institutional and organisational arrangements mainly in terms of *frictions* between activities. By contrast, *linkages* between activities are equally important reasons why transactions require institutional and governance structures.

This leads to a broader view because transaction cost theory usually focuses on transactions that can be seen as transfers of 'commodities', i.e. goods predominantly produced by engineered processes *within* designed systems set up by humans. By contrast, institutional analysis in nature-related sectors often

focuses on 'non-commodities'[2]; that means resources, goods and services whose transactions involve processes of self-organisation in ecosystems not completely engineered by humans, but often influenced or even disturbed by them (see Section 3.2). Consequently, institutional analysis in nature-related sectors should take into account additional properties of transactions due to physical characteristics particularly (but not exclusively) observed in natural systems, such as jointness and lack of separability, coherence and complexity.

This does not mean that the analytical framework and the specific transaction-based perspective developed by Williamson cannot be applied fruitfully to non-designed systems as it is to designed systems, but for this purpose its limited view that 'transaction costs are the economic equivalent to frictions in physical systems' (Williamson, 1985: 19) should be extended because governance costs also derived from the phenomenon of interconnectedness in systems. Regulation of regional water levels, for example, has an impact on plant growth and crop yields, biodiversity and wetland conservation, the appearance of landscapes, lakes and rivers, water provision for households, power plants and other industries, and consequently may cause problems of coordination and consensus building between many stakeholders. Both frictions and coherence can cause interdependencies between actors that have to be governed by institutional and organisational arrangements that are usually not costless. Not only 'friction costs' (Williamson, 1985: 18f) but also what could be called 'coherence costs' have to be taken into account; they may not be equally relevant and may play a different role in different physical systems.

Physical transactions can involve movement of goods between actors (e.g. when a farmer delivers wheat to his marketing cooperative). This type of transaction includes flows of physical (natural) resources between actors (e.g. when an irrigation manager, authorised by a water users' association, provides irrigation water to a farmer). Physical transactions not only include direct transfers from one or more actors to one or many others, but the transfers may be indirect, have a spatial dimension, involve time lags, be complicated to reproduce or even be hidden. They may be intended or unintended, targeted or non-targeted, predictable or unpredictable. The actors participating in a transaction may not know each other and it may be difficult to identify them all. Such properties of transactions are likely to play a greater role if they are related to natural systems than in the case of man-made systems.

However, a transaction does not always imply the movement of a physical object between actors (Schmid, 2004: 69ff). Selling or leasing land does not mean that the land is physically moved. The only requirement for an action to be also called a transaction is that the actors involved are affected due to a physical implication. Instead of suggesting that a transaction is in all cases a movement located somewhere in a physical system, we only assume that it always has some form of physical realisation that is relevant for the

2 The distinction between 'commodities' and 'non-commodities' has emerged from the discussions on multifunctionality of agriculture (see, for details, Van Huylenbroeck and Durand, 2004).

actors involved. Obviously, a transaction should be seen as a physical phenomenon that is induced by a decision of one or more actors and affects one or more actors. A major reason for assuming such a comprehensive definition is that all these different sorts of transaction have the potential to cause interdependence between actors, resulting in either conflicts to be solved or opportunities for cooperation. This is the very reason why both need to be regularised by institutions and governance structures (see, for a more detailed discussion of this causal connection, Section 7.1). In other words, there is also an equally important institutional side associated with a physical transaction. *Institutionalised transactions* represent transfers of entitlements or constraints on goods or resources which implies that they become regularised by institutions and governance structures, for example, a transfer of water rights on water markets or the governance of water use by water users' associations. In this view, transactions 'are the alienation and acquisition between individuals of the rights of future ownership of physical things' (Commons, 1934: 58). From this point of view, a transaction is a change in social relationships. It is the change in individual rights and mutual obligations that constitutes a transaction in this perspective (see Schmid, 2004: 69ff).

Like Williamson, Commons considers the transaction to be the basic unit of analysis, but do they mean the same thing? '... Williamson perceives a transaction to entail the transference of a good or service across a technologically separable interface; that is, it entails the transference of assets across discrete stages of multistage production process. In contrast, Commons perceives the transaction to be a unit of transfer of legal control, that is, to involve the transference of property rights. An important difference is subsumed in these conceptions of the transaction, for the transference of the right to withhold something from another who needs or wants it need not involve a movement of a good or service across a technologically separable interface' (Ramstad, 1996: 415). However, although the definition of a transaction prevailing in New Institutional Economics emphasises that a transaction takes place when a transfer over a technically separable interface occurs, it does not only look at one side of the coin when referring to the physical dimension. It explicitly includes the other side of the coin emphasising the social dimension. Williamson (2000: 599) (see also Williamson, 1996) explicitly refers to Commons' (1932: 4) demand that 'the ultimate unit of activity ... must contain in itself the three principles of conflict, mutuality, and order. This unit is a transaction', and he adds: 'Not only does transaction cost economics subscribe to the idea that the transaction is the basic unit of analysis, but governance is an effort to craft *order*, thereby to mitigate *conflict* and realise *mutual gains*' (italics in original).

## 3. Conventional views on properties of transactions and modes of governance

Transactions generated by choices and entailed in subsequent actions of actors can be described by the basic physical, chemical, ecological or biological

attributes of the elements they impact upon. However, this is not what economists and other social scientists are primarily interested in. They want to know what preconditions (obstacles or opportunities) these attributes provide for finding or designing social constructions able to regularise the actors' interdependencies resulting from the transactions. Therefore, transacted goods are usually not characterised by their physical, chemical, ecological or biological attributes directly but by the fit of a mode of governance to control these transactions. An example is the use of excludability and rivalry as criteria for distinguishing market goods from other goods. This terminology and classification is based on the question of whether markets as a social construction can govern a transaction or not.

In other words, a breakdown of this issue into three questions would be necessary:

- First, what are the basic attributes of the physical entities affected by transactions?
- Second, which properties of transactions originate from these attributes?
- Third, what do these properties imply in terms of institutional and organisational arrangements for governing these transactions?

The following sections will show that these three aspects are not always considered separately.

### 3.1. Externalities and public goods: defining non-private goods as a surrogate

The way the terms 'externalities' and 'private and public goods' are used in economics seems to be influenced by the market/state dichotomy, which still seems to influence perceptions. Economists tend not to use a direct definition of public goods, but rather an indirect definition referring to *non-private goods.* More precisely, we do not define private or public goods, but market and non-market goods (the latter traditionally being assumed to be managed by the state). This is due to the procedure underlying the definition:

- Two criteria are applied for defining the two classes of goods: *excludability and rivalry*. But these do not specify properties of goods themselves; they refer to the institutional and organisational fit of a social construction, that is, voluntary exchange between at least two agents. In this respect, they are market-oriented, i.e. they identify whether transactions of a good can be coordinated by markets or not.[3]
- This concept moves directly from the attributes of goods to the question of the institutional fit of the market and misses the intermediate step mentioned at the beginning of Section 3, an explicit consideration of the

3 This does not mean that these properties of goods cannot play a role for other modes of governance. Common pool resources, for example, which are often used as a common property by cooperative arrangement, do have the property of rivalry.

properties of transactions that may be compatible or incompatible with certain institutional and organisational arrangements.

- The two criteria cannot help us decide what other governance structures are suitable for coordinating transactions of goods that do not fulfil the criteria. They only give us an indication that these goods should be dealt with by *any other governance structure*.

This distinction between private and non-private goods reflects a dichotomy between a well-defined and an undefined institution and governance structure—a somehow incomplete dichotomy. Obviously, the properties of goods considered to be relevant are predefined by whether or not they fit with the market. This predetermined understanding makes the researcher's perceptive faculty selective: he recognises those properties of goods that are part of his internalised theory and cannot adequately perceive others that do not fit with his predetermined understanding (see Popper, 1974: 359).

### 3.2. Perception of properties of transactions in transaction cost economics

As already emphasised, the properties of goods used for distinguishing private and non-private goods are not relevant *per se*, but implicitly refer to the feasibility and the challenges of governance that arise during the process of transacting a good from the domain of one actor into the domain of one or more others. An extended and more differentiated view of this relationship has a strong tradition in transaction cost economics (Williamson, 2000). In particular, all three steps (mentioned in Section 3) necessary to identify institutional and organisational fit are taken by establishing empirically substantiated categories of properties of transactions, i.e. uncertainty, frequency and asset specificity. An example of this is the way the physical attribute of an asset consisting of its 'non-redeployability' to an alternative use gives rise to the property of transactions known as asset specificity and thence to the question of how to govern bilateral dependency between actors (Williamson, 1996: 59, 106). 'Discriminative alignment', i.e. the analytical process by which 'transactions are aligned with governance structures' (Williamson, 2000: 599) represents one of the core elements of transaction cost economics.

Nevertheless, the prevailing concepts of transaction cost economics seem to leave a gap as regards their applicability to nature-related transactions, because the properties of transactions it emphasises have been discovered in areas of production and trade where transactions are usually separable due to a high degree of decomposability, modularity and independence exists.[4]

4 '*Near-decomposability*' is a key term in Simon's (1969) research on a broad set of systems ranging from business organisations to biological systems. It denotes the property of complex systems that enables each of their subsystems to perform most of its activities with only weak impact upon, and interaction with, its other modules. *Modularity* corresponds with the notion of *building blocks* and refers to *additive partitions* (de Jong *et al.*, 2004: 2); it can be interpreted as a precondition of strong decomposability and follows the idea that optimisation of a subset of the variables in a system may be possible to some extent without taking into account other variables in the

As mentioned above, they have been established in the context of transferring 'commodities' – goods mostly produced by engineered processes that take place in designed systems set up by humans. Here, frictions in the system that separate activities are perceived as the reason why a transaction needs to be controlled by institutions and governance structures. This is different in the case of 'non-commodities' – goods and services, resources and amenities, but also damages and nuisances, which are to a large extent provided by, or through, self-organised ecosystems where human design plays a limited role. In this case, linkages between activities due to the coherence of the system and the interconnectedness of its parts explain why transactions have to be regularised by institutions and organisations. Both types of problem can cause interdependencies between actors to be governed. This adds another aspect to the view that 'transaction costs are the economic equivalent to frictions in physical systems' (Williamson, 1985: 19). Both 'friction costs' (Williamson, 1985: 18f) and what we might call 'coherence costs' play a role.

Accordingly, institutional analysis in nature-related sectors has to take into account additional properties of transactions resulting from attributes that can particularly be observed in ecosystems, such as jointness and absence of separability, coherence and complexity, limited standardisability and calculability, dimensions of time and scale, predictability and irreversibility, spatial characteristics and mobility, adaptability and observability, etc. For example, nitrogen fertiliser use by farmers represents a transaction that affects other actors due to the interconnectedness of the natural system in various ways – both desired and problematic – resulting in a complicated action situation. Applying high rates of nitrogen or manure to crops certainly increases yields and may under certain conditions also improve soil fertility. However, these beneficial effects are usually, particularly when soil management is insufficient, accompanied by numerous adverse effects[5] affecting third parties and having difficult and even unknown biochemical and geophysical implications. This leads to highly complex and interconnected transactions. Having a haircut is a contrasting example of a rather atomistic and isolated transaction.

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system. Additive partitions are closely associated with *separability* of modules. These concepts support the general idea that *inter-module interactions* are less relevant than *intra-module interactions*. However, modularity only indicates the *structural* interconnectedness of modules and reflects how likely *immediate* effects between two modules may be at the moment. It does not say anything about *dynamic* relationships between different modules *over time*, which determine how changes in the state of one module affect changes in the state of another module. These relationships reveal the extent of *functional* dependence of a module on another module, which again may differ between the *hierarchical* levels of a system. "Structural modularity does not imply isolation, or near independence, of the dynamical behaviour of modules" (Watson, 2002: 1f; see also Section 5).

5 For example, eutrophication of lakes and death of fish, emission of greenhouse gases ($N_2O$), biodiversity reduction and adverse health effects due to excessive nitrates in drinking water and certain foods.

## 4. Nature-related frameworks of institutional analysis

This section reviews a few approaches using frameworks of institutional analysis that explicitly focus on natural resources, environmental issues or products for which biological and ecological processes are crucial. One reason for this review is to see whether the causes, properties and implications of nature-related transactions identified in the previous section play a role in these approaches. We will also show some differences and commonalities of the concepts of governance.

### 4.1. Properties of transactions in nature-related institutional analysis frameworks

Vatn (2002: 314) argued that 'precision' is a relevant attribute of policies because of its impact on policy-specific transaction costs. There is a trade-off between the extra benefit of focussing a policy measure more precisely on its objective and the additional transaction costs this incurs. Vatn (2005) explored the optimal physical stage for regulating a process that generates harmful waste emissions: emissions, inputs, or the production or consumption processes. The precision of regulation and the transaction costs involved depend on the characteristics of the emissions, which determine the appropriate point of instrument application. This consideration of attributes does not focus on properties of transactions via natural systems, but on transaction costs incurred by environmental policies. Achieving a high degree of precision may be demanding because natural systems are complex. It requires knowledge about which physical or natural properties give rise to the need for precision and what this means for the design of nature-related institutions and governance structures.

Nature-related transactions also play an important role in consumer food economics, supply chain management and agricultural trade, and the institutional and organisational arrangements that have emerged for their governance can be successfully analysed by transaction cost economic approaches (Van Huylenbroeck, 2003; Ménard and Valceschini, 2005). Although processed and marketed goods originally produced in natural systems have passed through processes of modularisation and standardisation, this does not mean that they are free of the problems originating from interconnectedness in natural systems. The ecological and biological processes associated with the primary product maintain their relevance over all stages of the food chain, in particular, because they hinder decomposability and observability. As a result, food consumers cannot assess many intrinsic and relevant attributes of foods *ex ante*, or in some cases even *ex post*. These 'credence attributes' (Van Huylenbroeck, 2003: 199) lead to problems in monitoring food quality and safety. For Ménard and Valceschini (2005), the prevalence of credence goods is an aspect of the specificity of the agri-food industry with implications for governance. It demonstrates how 'asymmetric information between consumers and suppliers, combined with an increased

perception of uncertainty (. . .), leads to more and more requests for control over processes as well as control over products' (Ménard and Valceschini, 2005: 428).

The specificity of such transactions linked to the attributes of a natural system has motivated investment in traceability, as both 'an organisational answer to an endogenous informational problem' (signalling quality to consumers) and a certain 'guarantee about safety because it is backed by institutional devices' (whether private, public or mixed) (Ménard and Valceschini, 2005: 426). It is striking that the diversity of arrangements for governing quality control in the agri-food industry emphasised by Ménard and Valceschini corresponds with the diversity of the natural systems. Similar institutional and organisational diversity can be found as a result of post-socialist agricultural transition processes, which are another example of governing transaction-related agriculture's use of natural resources such as soil and water (see, e.g. Theesfeld, 2004; Beckmann and Hagedorn, 2007).

In her work based on the Institutional Analysis and Development (IAD) Framework, Ostrom (2005) emphasised that attributes of biophysical and material conditions and their transformation often affect the variables of an action situation: 'What actions are physically possible, what outcomes can be produced, how actions are linked to outcomes, and what is contained in the actors' information sets are affected by the world being acted upon in a situation. The same set of rules may yield entirely different types of action situations depending upon the types of events in the world being acted upon by participants'. She uses the criteria of excludability and rivalry for defining not only private and non-private goods, but also toll goods and common-pool resources that 'yield benefits where beneficiaries are hard to exclude but each person's use of a resource system subtracts units of that resource from a finite total amount available for harvesting' (Ostrom, 2005: 24–28).

Ostrom considers various additional physical conditions to be at least as important because it is the combination of rules with physical and material conditions that generates positive or negative incentives relevant to a specific setting. A set of rules may transform into incentives stimulating productive outcomes in one setting, but may fail in another setting where the physical and material context is not the same. From the numerous studies on common-pool resources available, Ostrom (2005: 26) draws the conclusion that, 'for example, effective rules depend on the size of the resource; the mobility of its resource units (e.g., water, wildlife, or trees); the presence of storage in the system; the amount and distribution of rainfall, soils, slope, and elevation; and many other factors' (see Ostrom *et al.*, 1994).

Young (2002) also acknowledged the 'institutional dimensions of human–environment interactions'. Here, the relevance of the biophysical conditions is revealed in what he calls 'the problem of fit'. An institutional arrangement should be well matched to the properties of the biophysical systems it impacts upon because this improves the outcomes of actors' behaviour when they use or protect a physical or natural system.

### 4.2. Forms of governance in nature-related institutional analysis frameworks

The categories of governance offered by transaction cost economics are limited to markets, hierarchies and hybrids. But are these choices sufficiently differentiated and flexible given the diversity of rules and the plurality of organisational solutions that may be required for coping with nature-related transactions and the resulting interdependencies among actors?

As the biophysical conditions relevant for the choice of rules in use and modes of organisation are numerous and heterogeneous, Ostrom (2005) concludes that *institutional diversity* and *polycentric governance* are needed to regularise human–environment interactions. The term 'polycentric system' was introduced in the literature on governance systems in a classic article by Ostrom *et al.* (1961: 831) who used this term to describe 'the traditional pattern of government in an urban area with its multiplicity of political jurisdictions'. At first glance, this notion of governance seems quite different from the one used in transaction cost economics (see also Hanisch and McGinnis, in press). However, this would be a rash conclusion given the diversity of governance structures that can be found in the area of *hybrids*. Since the definition of hybrids refers to markets and hierarchies as primary points of reference, it may seem at the theoretical level that hybrids are a marginal category. In fact, in empirical research it has become a very rich category with respect to its variety and social construction of governance.

Ménard (2004) has explored hybrids comprehensively (see also Verhaegen and Van Huylenbroeck, 2002; Van Huylenbroeck, 2003; Ménard and Valceschini, 2005), describing the heterogeneity of arrangements within this category and identifying regularities found in the related literature (Ménard, 2004: 347). Characteristics comprising a minimum requirement for a governance structure to be identified as a hybrid are 'agreements among legally autonomous entities doing business together, mutually adjusting with little help from the price system, and sharing or exchanging technologies, capital, products or services, but without unified ownership' (Ménard, 2004: 348) and arrangements that fulfil these criteria are: subcontracting, networks of firms, supply-chain systems, franchising, collective trademarks, partnerships, cooperatives and alliances among firms (Ménard, 2004: 351).

The empirical regularities revealed in this way are 'pooling, contracting and competition'. They are likely to represent the basic constitution of hybrids:

1. Partners who associate in hybrids pool some of their resources but without collectivising their property rights. Hence, they retain their rights to make individual decisions. In such a setting, the selection of partners, the planning of joint investments and the development of reliable ways of communication are crucial issues for the viability of the organisation.
2. The prevailing mode of governance for coordinating the individual choices originating from separate rights of decision-making resides in contractual relationships. The contracts provide blueprints that are usually very incomplete and do not account for specificities.

3. In hybrid arrangements, partners are subjected to competition both among themselves and other hybrids and other types of organisation. This requires rules and arrangements for benefit sharing and dispute resolution (Ménard and Valceschini, 2005: 424).

The combination of these characteristics of hybrids implies that the activities of the partners need to be harmonised and the conflicts between them must be solved. This requires tailored governance structures because neither the command and control mechanism nor the price mechanism can fulfil this task for hybrids. 'Forms of 'authority' emerge to govern these complex relationships' (Ménard and Valceschini, 2005: 424; see also Ménard, 2004: 351–354).

Van Huylenbroeck (2003) and Verhaegen and Van Huylenbroeck (2002), following similar ideas, developed an applied classification of hybrids derived from their empirical research on different forms of agricultural marketing. They distinguish 'framework or open group governance' established to cover investments in market separation and which only enforce minimum standards, 'coordinated or club governance' which exerts stronger influence on members in order to achieve a match between the production and the demand from retailers, and 'participating or captain-of-channel governance' with a 'strong transfer of power to one central authority', for example, when a uniform quality is required (Van Huylenbroeck, 2003: 199–202). Reconciling the interdependence of partners, which, for example, originates from interdependent investments, with their legal autonomy, as property rights remain separate, is a key challenge in governing hybrid arrangements. Due to this combination typical for hybrids, asset specificity and insecurity become crucial properties of transactions, creating incentives for opportunistic behaviour that require mechanisms to control and discipline the partners (Ménard, 2004: 351–357).

The convergence of the perception of hybrids in transaction cost theory towards the vision of polycentricity as developed by the Bloomington School is quite striking, as can be seen by comparing the following two quotes: 'What makes these regularities characteristic of hybrid arrangements is that ... they rely on partners who maintain distinct property rights and remain independent residual claimants' (Ménard, 2004: 351–354). This is completely in line with the characteristics of polycentric systems suggested by Ostrom *et al.* (1961: 831): ''Polycentric' connotes many centers of decision making that are formally independent of each other. ... To the extent that they take each other into account in competitive relationships, enter into various contractual and cooperative undertakings or have recourse to central mechanisms to resolve conflicts, the various political jurisdictions in a metropolitan area may function in a coherent manner with consistent and predictable patterns of interacting behavior. To the extent that this is so, they may be said to function as a 'system''. The main design principles of hybrid and polycentric organisation are very similar: independence of the cooperating units, coordination by contractual arrangements and some centralised authority for

dealing with issues of distribution and conflict. The observation that the two approaches differ as regards the categories and terminology they use may be explained by their different disciplinary origins and areas of application. The concept of hybrids has developed in the context of private regulation in production economies, whereas the concept of polycentricity emerged from research on the governance of public economies (see also Wagner, 2005), although also in the latter domain one finds forms of governance that can be seen as hybrids, such as environmental cooperatives for farmers (Slangen and Polman, 2002).

Apart from the work of Ostrom and researchers using similar concepts, who explicitly emphasise this point,[6] the approaches discussed in this section do not suggest that complexity and interconnectedness as basic attributes of natural systems are systematically taken into account. Their causal connection with transaction properties and the choice of institutional and organisational arrangements does not seem analytically established. Diversity of institutions and heterogeneity of governance modes have been clearly revealed by empirical research in the domain of hybrids, which has focused on agricultural marketing, where biological and ecological processes are equally important, but less on agri-environmental issues. This is in line with the observation made by Beckmann (2002: 8) that 'Williamson had no real impact on environmental and resource economics. There may be two reasons. First, the unit of analysis, the transaction, may not be adjusted to the problem setting of environmental and resource economics. Second, the main focus on markets and hierarchies may be not adjusted to the solution set discussed in environmental and resource economics, which focuses very much on state intervention and the choice of instruments by governments'.

## 5. Properties of transactions related to natural systems

Perhaps the properties of nature-related transactions can only be assessed on a case-by-case basis. However, this would not be very satisfying from a conceptual point of view, since without an operational system of classification it could be difficult to establish causal relationships between natural system attributes, transaction properties and social constructions for regulating and governing nature–human interactions and actor interdependencies. This motivates the search for a heuristic framework for ordering nature-related transactions that could capture the essential of this heterogeneity and diversity.

### 5.1. Modularity and decomposability

Properties of transactions depend on the attributes of physical systems, particularly those of the targeted part of the system, but also often of the wider context of the system in which the transaction is located. For example, the

6 See also Ostrom's proposal on conceptually decomposing social–ecological systems in Section 6.3.

way in which the application of nitrogen on a farmer's field influences the living conditions of fish in an adjacent lake, and hence its use by fishermen, not only depends on the direct run-off of water and the soil surface, but also on complicated processes in the hydrological and geophysical systems. We suggest that *modularity and decomposability of structures* and *functional interdependence of processes* should be considered key attributes for ordering these phenomena.

Kauffman (1995) showed that when a system has reached a certain level of complexity or interconnectedness, it is likely to have undergone a dramatic transition. Such systems will overcharge the intellectual capacity of humans used to applying a problem-solving procedure that decomposes a large problem into a set of smaller sub-problems capable of independent analysis (Simon, 1983). This strategy, which assumes full modularity and decomposability, also prevails in economic analysis.

Marengo *et al.* (2001: 9) called this assumption of complete modularity the 'granularity of the economics world'. The Coase theorem assumes perfect modularisation of an economy. 'In spite of its name Coase's theorem is rather a circular argument that states that if every single activity which affects agents' welfare can be exchanged and allocated in a perfectly competitive market then non-separability ceases to be a problem. . . . In the language of modularity we could say that the problem of externalities arises because we are working with modules that are too large, thus the solution is to disassemble them and let market selection operate on finer units' (Marengo *et al.*, 2001: 10). The tautology referred to can be summarised by the statement that lacking modularity is no problem if complete modularity exists. In this view, transaction costs are a result of inappropriate modularisation. Totally atomistic modularisation would be in line with Coase's idea of complete absence of transaction costs. If modules were too small or too large, they would smoothly reassemble or split up into optimal bundles. 'Any large computation should be split up and implemented as a collection of small sub-parts that are nearly independent of one another' (Marr, 1976: 485, cited by Velichkovsky, 2001: 354).

Completely modular and atomistic structures allow for transactions that can be easily subjected to social construction. However, in the complete absence of modularity, 'a small change in one place will have consequences in many other places. This means that the process as a whole becomes extremely difficult to debug or to improve, whether by a human designer or in the course of natural evolution, because a small change to improve one part has to be accomplished by many simultaneous compensating changes elsewhere' (Marr, 1976: 485, cited in Velichkovsky, 2001: 354). In such complex structures, modules will not smoothly break down or reassemble into optimal bundles.

### 5.2. A heuristic concept for ordering nature-related transactions

Do complete modularity and decomposability of structures also mean that no or little interdependence between modules exists? Simon (1969) suggested

that 'nearly decomposable' systems show only weak interactions between modules and allow subsystems to behave nearly independently. 'This fits with the common intuition that modularity is synonymous with the property that inter-module interactions are somehow less important than intra-module interactions. In fact, it is often assumed that a modular system cannot have strong significant inter-module interactions *by definition*' (Watson, 2002: 1; italics in original).

Watson argued that this interpretation is 'over-simplistic' and that interactions between sparsely interconnected modules may nevertheless be crucial if the dynamic properties of modules are interdependent and if functional properties depend on dynamic properties. A system's structural modularity should not be confused with its functional behaviour, and low structural modularity and decomposability may be associated with different degrees of functional interdependence of processes at different scales of a system. Moreover, Watson emphasised that 'one module may be strongly and nonlinearly sensitive to small state changes in another module despite being sparsely connected' (Watson, 2002: 1ff).

The terminology used in Table 1 builds on the following assumptions:

1. Transactions that occur physically within structures with high modularity and decomposability can be atomistic and are therefore rather simple to deal with.
2. By contrast, low modularity and decomposability imply that the subunits are multifaceted aggregates, which makes the transaction a more complex task.
3. Transactions can occur in a more isolated manner if their physical realisation is related to processes with low functional interdependence.
4. By contrast, high functional interdependence results in a higher degree of interconnectedness of transactions.

The ordering criteria adopted in Table 1 lead to four categories of transactions that follow the line of increasing coherence of physical systems and may at the same time reflect a shift from designed, man-made systems to non-designed, natural systems. It seems sufficient to select only the two extreme

**Table 1.** Attributes of systems guiding the ordering of properties of transactions

| | | Modularity and decomposability of structures | |
|---|---|---|---|
| Functional interdependence of processes | | High | Low |
| | Low | Atomistic-isolated transactions | Complex-isolated transactions |
| | High | Atomistic-interconnected transactions | Complex-interconnected transactions |

cases as a frame of reference. Accordingly, we will call those physical transactions that occur within nearly completely modular and decomposable structures where processes have a low degree of functional interdependence *atomistic-isolated transactions*, and *complex-interconnected transactions* those transactions that occur within structures with a very low degree of modularity and decomposability and with a high degree of functional interdependence of processes. Hence, classification of transactions based on the structural and functional attributes mentioned above can be oriented along a gradual continuum between atomistic-isolated transactions and complex-interconnected transactions.

Atomistic-isolated transactions are not confined to man-made, designed systems nor are complex-interconnected transactions present only in natural systems not designed by humans. Indeed, numerous counter-examples could be found. However, this idea may enable institutional analysts to identify and order heterogeneous transactions, particularly those found in domains where actors use, manage, degrade and protect natural systems.

## 6. Characterising transactions in interacting social and natural systems

How can the heuristic framework developed in Section 5.1 lead to a typology? The first step would be to explore whether and to what extent conspicuous properties of transactions (such as *excludability and rivalry*, *asset specificity*, *frequency and uncertainty*, *jointness and separability*, *coherence and complexity*, *standardisability and calculability*, *dimensions of time and scale*, *predictability and irreversibility*, *spatial characteristics and mobility*, *adaptability and observability*, etc.) can be systematically explained and better understood according to the ordering criteria used in Table 1. For example, asset specificity is closely connected to the extent of modularity and decomposability of physical assets, and jointness, a core aspect of multifunctionality, results from mutual dependencies of processes in ecosystems. Such an effort may enable us to situate various types of transaction along the continuum between atomistic-isolated transactions and complex-interconnected transactions and discover more concrete reasons for their differences in properties. However, for the moment it remains to be seen whether the categories chosen in Table 1 are sufficient or whether additional ones are needed.

Establishing such a typology would require processing considerable interdisciplinary knowledge and empirical information, which can only be achieved in a cumulative research process. Hence, we do not aim for such a result in this paper. Instead, we will show why it would be useful in terms of linking the physical and the institutional dimensions of nature-related transactions in order to specify how nature-related transactions can be regulated by the appropriate choice of institutions and governance structures. Concepts of interaction between humans and their natural environment discussed in the following section share this view.

### 6.1. Ecosystem–human system characteristics: stocks, flows, controls, attributes

The 'ecosystem–human system model' presented by Low *et al.* (1999: 228) (see also Costanza *et al.*, 2001) distinguishes three domains: *ecosystem characteristics*, *interaction characteristics* and *human system characteristics*. 'Both ecological and social systems have 'stocks,' 'flows', and 'controls' of those flows. All stocks, flows, and controls have attributes. . .. The interaction sector, where human decisions affect resources in ecosystems, lacks stocks; it has flows, controls, and attributes' (Low *et al.*, 1999: 232). The stocks of the social and the natural systems are renewable and non-renewable resource stocks, man-made capital and human capital, and flows result from regeneration by births, degeneration by deaths, harvesting from resource stocks, interest, taxes, investment and depreciation of capital. The authors emphasise the function of controls such as physical, behavioural and legal constraints that regulate flows in all three domains.

The same attributes of stocks and flows are identified in the ecological and human systems: heterogeneity, predictability, resilience, decomposability, range of variation, extremeness, extent in space and time and productivity (Low *et al.*, 1999: 228, 233). The interactions between the human and the ecosystems are considered as a domain that has its own set of attributes described as excludability, observability, enforceability, divisibility and sustainability (Low *et al.*, 1999: 233). Remarkably, interactions are separated from the ecological and human systems, although they occur within their intersection. This suggests that human activity is placed into a physical rather than a causal arrangement vis-a-vis the two systems.

### 6.2. The biocomplexity approach: institutional analysis in biodiversity governance

Jungcurt *et al.* (2005: 12) present a 'stylisation of common resource-use perspectives on various aspects of ecosystem goods and services'. They define a resource-use perspective by referring to a group or series of transactions that are closely associated, take place at the same time and involve at least one identical actor or actor group. This applies, for example, when a farmer buys grain as seed and sells cereals as food. The transactions are considered to be clustered because either they do not take place in isolation or they are inextricably connected. This accounts for what we identified as modularity and decomposability of structures and functional interdependence of processes. 'Many aspects of decisions regarding a transaction X may in fact be related to attributes of the good that are relevant only in the context of another transaction Y. The actor already has Y in mind when performing X. Thus, there is an implicit link between [the] two transactions that would be ignored if we were to analyse each transaction in isolation' (Jungcurt *et al.*, 2005: 13).

The authors illustrate their idea by referring to transactions in crop production and discussing the relationships between seeds and plants, genotypes

and phenotypes, and harvest and products where limits of observability and problems of transparency are typical for the governance of transactions. For establishing causal relationships that define resource-use perspectives, they distinguish between the biophysical attributes of the ecosystem good or service and the properties of the transaction. This allows them to describe the relationship in terms, first, of a causal link between the biophysical attributes and the properties of the transaction, and then between the transaction properties and the governance modes (Jungcurt *et al.*, 2005: 16; see also Daedlow *et al.*, 2007).

At first glance, this differentiation seems to be similar to the distinction between ecosystem and human systems and the interaction domain as a third unit in the previous section. However, this model depicts an arrangement of *physical components*, whereas the biocomplexity concept refers to the *causality between conceptually segregated categories*. The importance of this difference will become even more apparent in the following section.

### 6.3. Towards conceptual decomposability of social–natural systems

In a recent article, Ostrom (2007) warned of the danger of blueprint approaches to the governance of tough social–ecological problems and emphasised the ineffectiveness of universal panaceas that scholars derive from simple, predictive models of social–ecological systems (SESs). 'Moving beyond panaceas to develop cumulative capacities to diagnose the problems and potentialities of linked SESs requires serious study of complex, multivariable, nonlinear, cross-scale, and changing systems'. To this end, she proposed doing justice to complex realities by applying diagnostic methods to find combinations of variables that structure the incentives and guide the actions of actors who are subjected to diverse governance systems. In particular, she recommends paying attention to the nested attributes of a resource system and identifying the resource units provided by that system. These two entities jointly shape the incentives of users in conjunction with the constraints resulting from a set of rules. The latter are crafted by local, distal or nested governance systems (Ostrom, 2007: 15181).

Assuming the partial decomposability of complex systems, Ostrom (2007) develops a general framework that builds on the IAD Framework (Ostrom, 2005). She uses the following broad categories to 'organize an analysis of how attributes of (*i*) a resource system (e.g., fishery, lake, grazing area), (*ii*) the resource units generated by that system (e.g., fish, water, fodder), (*iii*) the users of that system, and (*iv*) the governance system jointly affect and are indirectly affected by interactions and resulting outcomes achieved at a particular time and place' (Ostrom, 2007: 15182). Such a framework is flexible as regards the inclusion of interdependencies to higher and lower scales in institutional analysis. The attributes mentioned above are embedded in larger ecological, social, economic and political settings and also contain smaller ones.

What makes this research strategy unique is that it transposes an analytical objective that cannot be achieved straightforwardly at the physical level to the

conceptual level for analysis.[7] In terms of our heuristic ordering of nature-related transactions used in Table 1, this would mean:

(a) if modularity and decomposability of structures do not hold at the physical level, we should try to decompose the complexity at the conceptual level; and similarly
(b) if functional independence of processes does not exist at the physical level, we might at least make the interrelatedness transparent at the conceptual level.

Using a similar strategy, we take the process leading from an '*ex ante* institutional change situation' (where a physical transaction is planned or has already occurred without being institutionalised) to an '*ex post* institutional change situation' and break it down conceptually into stages through which physical transactions become institutionalised transactions (see also Section 2.2). The sequence of these stages will be called the *'transaction-interdependence cycle*' (Figure 2) (see also Hagedorn, in press). After that, we will show that the continuum of atomistic-isolated transactions and complex-interconnected transactions being part of this cycle calls for a corresponding spectrum of institutional and organisational choices that accounts for the principle of discriminating alignment when matching properties of transactions with the regularising capacity of institutions and governance structures.

## 7. The transaction-interdependence cycle and integrating or segregating institutions

Transactions originating in decisions made by actors may often also affect other actors who were not involved in those decisions. This creates interdependence between these actors and may provoke either conflict that requires solutions or synergies that enable mutual benefits from cooperation. Therefore, we have to look at the transaction-interdependence phenomenon from two different angles: the (physical) transaction of a good or resource and the (social) interdependence between actors or organisations.

### 7.1. The transaction-interdependence cycle

The transaction-interdependence cycle includes the following stages (see Figure 2):

1. Actors choose an action (e.g. to use water for irrigation, to apply nitrogen fertiliser) that entails transactions involving one or more actors.
2. Such choices lead to a transfer of resource units (quantities of pumped water) or they affect ecosystem components by resource users (nitrate in water flows in soil).

7 Another approach called coupled human and natural systems (see Liu *et al.,* 2007) takes a more macro-analytical view and differs in this respect from the micro-analytical perspective preferred in this paper.

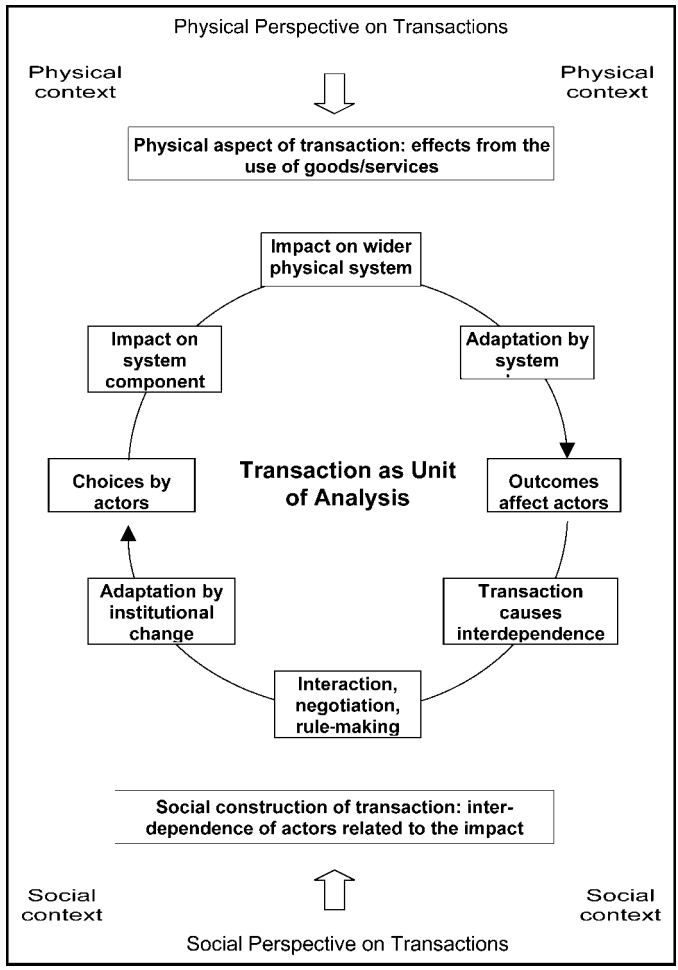


**Figure 2.** The physical and the social perspectives on the transaction as the basic unit of analysis: the transaction-interdependence cycle.

3. They may also impact on the wider context of the physical or natural system (extraction of groundwater resources exceeds regeneration, eutrophication in an adjacent lake).
4. Ecosystems or hydrological systems respond to these changes by adaptation processes (decline of regional water table, loss of parts of the fish population).
5. The outcomes affect other actors: a physical transaction occurs (households experience increasing scarcity of drinking water, fishermen lose part of their income).
6. The relationship between the actors participating in the transaction changes as they recognise their interdependence regarding the use of the natural system and respond to it.

7. This stimulates interaction between actors directly (water users) and indirectly (politicians) such as discussion, negotiation, consensus-building on rule-making.
8. Adaptation processes in the social system (e.g. regarding rules and organisation of water use and water pollution) result in institutional change and new governance structures.

As the transaction is now institutionalised, actors will adjust their choices to the new rules and enforcement mechanisms. If the actors involved accept the outcomes of the public and private ordering achieved, the transaction-interdependence cycle will end, otherwise it may start afresh and lead to additional institutional and organisational change.

This stylised approach to achieving conceptual decomposability reveals that the physical and the social perspectives are difficult to separate in institutional analysis of nature-related issues. This is because transactions and their properties must match the capacities of institutions and governance structures. Actions of one actor that imply transactions involving one or more other parties cause conflicts, or enable cooperation, and thus affect social relationships. Institutions emerge as a response to such conflicts or opportunities of cooperation, spontaneously or by design. This double-sided explanation of why institutions arise, exist and change is important because it is transactions that cause or reveal interdependence between actors, particularly when environmental resources are scarce and agents' interests are incompatible. For Paavola and Adger (2005: 355), these conflicts have to be resolved by defining (or redefining) initial endowments. Of course, in some cases interdependence may reveal win–win situations that call for cooperation.

## 7.2. Integrative and segregative institutions

The transaction-interdependence cycle may be conceived of as a conceptual map for organising research. What are the main research challenges suggested by this conceptual map? Each of its categories could be progressively broken down into multiple conceptual layers, one being the elaboration of a detailed and concrete typology of transactions using the heuristic framework presented in Section 5.1, arranged against the background of the continuum between atomistic-isolated and complex-interconnected transactions (Section 6). Closely associated with this, a second one would conform to what Williamson calls 'the main case hypothesis out of which transaction costs economics works . . .: align transactions (which differ in their attributes) with governance structures (which differ in their costs and competencies) in a discriminating (mainly transaction cost economizing) way' (Williamson, 1996: 46f). The discriminating alignment that corresponds with the just mentioned continuum of transactions may be found in the dichotomy of 'integrative and segregative institutions'.

Governing transactions institutionalised as indicated in the transaction-interdependence cycle would cause *transaction costs*. Integrative institutions

contain rules that hold decision-makers liable for the transaction costs they cause, they have the duty to internalise them and no right to externalise them. Segregative institutions soften this restriction to different degrees, relieving decision-makers from transaction costs and placing their burden (partially) on others. The second governance issue refers to the *effects of the transactions on actors.* For such transactions, the question of who is allowed to profit from the effects or who has to accept liability for them is relevant. Integrative institutions are rules that make the decision-makers eligible for the beneficial effects they cause and hold them liable for the adverse effects. Segregative institutions allow deviations from this principle so that the decision-makers may forego some benefits, which then accrue to others, but their liability for some adverse effects may also be reduced in the sense that others have to accept nuisances.

In the case of atomistic-isolated transactions, it is reasonable to assume that the issue of integrative or segregative institutions is hardly relevant because transaction costs are low and the effects of transactions are less complex and do not affect many actors. The opposite is likely to apply to complex-interconnected transactions. If processes of transaction have a degree of interconnectedness and diversity, and if the effects of transactions are rather complex and numerous, affecting many heterogeneous actors, an important question becomes whether the produced costs and nuisances, or benefits and amenities, should remain with those whose decisions generated the transaction or may be reallocated to others. In the latter case, questions include to whom these cost and benefits should be allocated, and why and how this should be done.

## 8. Conclusion

The starting point of this paper was a specificity of the 'green sectors' – agriculture, horticulture, fishery and forestry – that has received insufficient attention in the analytical frameworks and concepts used in both agricultural and institutional economics. Our discussion supports this diagnosis as it confirms that nature-related transactions are an under-researched topic. This is not hard to explain, as progress in knowledge about this complex issue cannot just be plucked out of the air. It requires not only interdisciplinary knowledge, but also an appropriate heuristic basis and conceptualisation, the lack of which sometimes creates a bottleneck for really enlightening research processes. In this regard, being reluctant to conflate the two aspects of a transaction – its physical and institutional dimensions – turns out to be useful and paves the way for more analytical categorisation.

Two main conceptual maps are provided by this paper: a heuristic framework to serve as the basis of a typology for nature-related transactions and a transaction-interdependence cycle that shows how a transaction becomes institutionalised. It is evident that employing such strategies of conceptual decomposability draws substantially on two micro-analytic traditions of institutional analysis, transaction cost economics and the Bloomington School

both associated with successful communities of scholars. Our analysis shows that combining frameworks and concepts taken from these two schools is promising. Future research on nature-related transactions and institutions should use these synergies.

These heuristic concepts are intended to stimulate further research and will raise expectations. Building on the degree of modular and decomposable structures and the density of functional interdependence of processes may successfully lead to an applicable typology that takes atomistic-isolated transactions and complex-interconnected transactions as opposite end-points, but this remains to be seen. This also applies to the suggestion made at the end of Section 7.2 that discriminating alignment based on integrative and segregative institutions can be applied to complex-interconnected transactions. It is clear that for governing such properties of transactions, the question of how much integration or segregation should be achieved by means of establishing and implementing respective sets of rules and modes of organisation becomes relevant. However, we have to be aware that such conclusions are to some extent based on plausibility, and anomalies quickly appear in a deeper analysis (see Hagedorn, in press). For both research challenges identified at the end of this paper, further research will hopefully reveal surprises that will stimulate attempts to revise and enrich the suggested frameworks and concepts.

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