Transaction cost economics theory applied to the investment in natural capital: questioning the compensation of biodiversity destruction

Pierre Scemama[ab]

Harold Levrel[a]

[a] IFREMER, UMR AMURE, Département d'Economie Maritime, BP70, 29280 Plouzané, France

[b]Corresponding author: pierre.scemama@ifremer.fr

1. Introduction

According to economic theory, the social welfare of populations in a given period depends on the utility generated by consumption of goods and services available at this time (Ramsey, 1928). The useable goods and services are produced from the use of a capital stock as input by a production process. Future consumption and therefore the social welfare depend on the current stock of capital (Mäler et al., 2008).

There are different types of capital involved in production functions: manufactured capital (fixed assets, production equipment and finished products), human capital (anything that contributes to the labor force released by man as the education or health) and natural capital.

Natural capital refers to the limited stocks of physical and biological resources that are causing the flow of goods and services provided by ecosystems (Costanza and Daly, 1992). The Millennium Ecosystem Assessment identifies four categories of ecosystem services: provisioning services that return to natural resources exploited directly, regulating services that represent the ecosystem functions such as water purification or recycling of waste; support services which are the basic processes necessary for the reproduction of life on Earth; cultural services that are related to recreational activities in connection with nature and feeling of well being in general (Millenium Ecosystem Assessment, 2005).

Despite recognition of the renewable aspect of natural capital[1], the latter is subjected to severe erosion for two reasons (UICN, 2009; Butchart et al., 2010; Hoffmann et al., 2010). The first is the increase of human activities that degrade ecosystems through overexploitation, introduction of invasive species, pollution and destruction of habitat or climate change (Sala et al., 2000; Balmford and Bond, 2005). The second is the lack of investment in natural capital and biodiversity which produce ecosystem services.

The neo-classical economics is based on the principle that economic agents behave rationally and that they make their decision based on "price signals" sent by the market. The lack of investment in natural capital would be due to the lack of information about its value, without which individuals cannot make the right choices (Daly and Cobb, 1989). It is in this sense that have been developed a set of tools to estimate the economic value of the environment[2]. The idea is that if one evaluates the economic and ecosystem services and establishes property rights over them, then they could be considered market goods that meet the law of supply and demand.

Much work has been performed to estimate the economic value of natural capital. They can be separated into two categories. First, large-scale studies among which we mention the work of TEEB who calculated the cost of policy inaction facing erosion of biodiversity to 13,938 billion Euros for the period 2000-2050 (Braat and Ten Brink, 2008). The value of

[1] Natural capital can be divided into four categories (Clewell and Aronson, 2010): renewable natural capital (living species and ecosystems), replenishable natural capital (the ozone layer, clean water, etc ...) , cultivated natural capital (crops, forest plantations, etc ...) and non-renewable natural capital (oil, minerals, etc ...). The first three are opposed to the last in the sense that they can be exploited to comply with their rate of renewal (eg Maximum Sustainable Yield for fisheries), while non-renewable natural capital would be analogous to a stock of goods whose operation led to the liquidation of a part of the stock (Rees, 1995).

[2] For an overview of these techniques see (Freeman, 2003) and (Mäler and Vincent, 2005)

annual flows of ecosystem services provided by nature has also been estimated at 33,000 billion per year (Costanza et al., 1997), and 2 000 billion per year for coastal ecosystems (Martínez et al., 2007). In France, such studies have been conducted and have evaluated the reference value for all the ecosystem services provided by the French forest about 970 Euros per hectare per year (Chevassus-Au-Louis et al., 2009).

A second category of assessments concerns those made at finer scales for applying cost-benefit analyzes related to development projects or conservation on a local scale. These studies are many as shown by the existence of several databases enabling to the compilation of their results (McComb et al., 2006). Of these, the database EVRI (Environmental Valuation Reference Inventory) contains more than 2500 studies.

Despite the proliferation of these assessments, their impact in terms of political decisions remains low. This was shown by Fisher et al. (2008) from an analysis of 34 case studies. Thus despite the mounting evidence of economic benefits that derive from the nature conservation, investment in biodiversity do not increase (Balmford et al., 2002). Which allows us to question the relevance of these arguments to address the problem of under-investment in natural capital.

In this paper we propose a reading of the market creation of ecosystem services through the theories of neo-institutional economics. Initially we will discuss what are the points that oppose the neo-classical organizational theory to show why the latter can offer opportunities to address the under investment in natural capital. We then apply this reading to the case of the creation of the mitigation banking for wetlands in the U.S. and thus identify the levers that can improve the capital investment.

2. The prism of neo-institutional economics

2.1 The Transaction Cost Theory

The flaws of the neoclassical theory and its system of coordination by prices of the economic activity and the allocation of resources were highlighted by Coase. The latter showed the existence of costs associated with the use of the price system: the transaction costs (cost of determining a fair price, cost of negotiating and contracting) (Coase, 1937).

The market is coordinated by the price system, while the company is coordinated by the entrepreneur. As a result, even if transaction costs do not disappear, they are greatly reduced. Coase's proposal is that there is a level of transaction costs for which it will be more interesting to use coordination by the company rather than through the price system.

According to Coase, transaction costs are crucial in the decision of the vertical integration of a production within an organization (whether public or private). This goes even further by saying that in the absence of transaction costs, the allocation of property rights is automatically optimally by direct negotiation between the agents and, whatever the initial distribution of these rights (Coase, 1960). Without transaction costs, the issue of organizational choice to oversee a transaction does not arise.

The importance of transaction costs in explaining the emergence of alternative organizational forms in the market, will be reused by Williamson in the Transaction Cost Theory (TCT) which aim at explaining the choice of governance structure of a production activity based on the characteristics of the transaction arising from this activity (Williamson, 1979, 1985, 1996).

In the TCT, in contrast to neoclassical theory, economic agents are not considered to be rational, but as having a bounded rationality[3] and an opportunistic behavior[4]. Bounded

[3] Agents are unable to anticipate ex ante all states of nature. This hypothesis was first raised by Simon described as economic agents whose behavior is "intentionally rational, but only to a limited extent" (Simon, 1961).

rationality of economic agents involved in a transaction[5] makes impossible the establishment of a contract that is sufficient to fully coordinate the agents. Furthermore the assumption of opportunism emphasizes the need to construct contracts that constitute sufficiently credible commitments to guide the behavior of agents and thus secure the object of the transaction. Contracts are supplemented by other coordination mechanisms, which thus form the governance structure. There are three types: markets, hierarchies and hybrid forms[6]. The problem to the contractors is to choose the more efficient governance structure, that is to say the one which minimizes transaction costs and production costs. However, the theory holds that in most cases, these are considerations in terms of transaction costs that explain the choice of organizational forms (Saussier, 1997).

The fact that the analysis of organizational forms requires direct comparison of transaction costs has been criticized particularly important because these costs are difficult to observe and measure in an existing structure, but they cannot be investigated for alternative forms that are not yet existing (Masten et al., 1991). To address these criticisms, the theory has

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[4] The assumption of opportunism of agents corresponds to a strategic behavior of agents by which they will seek to exploit gaps in the contractual relationship for their own interest (Williamson, 1993).

[5] Both sides of the transaction and the third party responsible for enforcing the commitments made in connection with the transaction.

[6] Here the market is the same concept as that used by the neo-classical economics, that is to say a control system coordinated by the price signal. The hierarchy refers to the hierarchical and generally centralized structure of the integrated firm (public or private) that is based on ties of subordination between the agents. Hybrid forms cover a variety of arrangements such as long-term contracts, alliances, franchising, brands or manufacturing licenses, etc.

sought to link the cost of a transaction with certain characteristics and then lay the foundation for the discussion on these observable characteristics.

These characteristics include three things: the uncertainty surrounding the transaction, the frequency at which the transaction occurs and the degree of specificity of assets involved in the transaction (Williamson, 1979). It is based on discussions on these characteristics that the theory compares the different governance structures.

2.2 Transaction cost theory applied to environmental issues

The TCT gives special importance to asset specificity and states that in a context of uncertainty, if the specificity of assets associated with a transaction increases, then the choice of the governance system will evolve away from the market to move closer to vertical integration (Figure 1). Here the market is the same concept as that used by the neo-classical economics, that is to say a control system coordinated by the price signal.

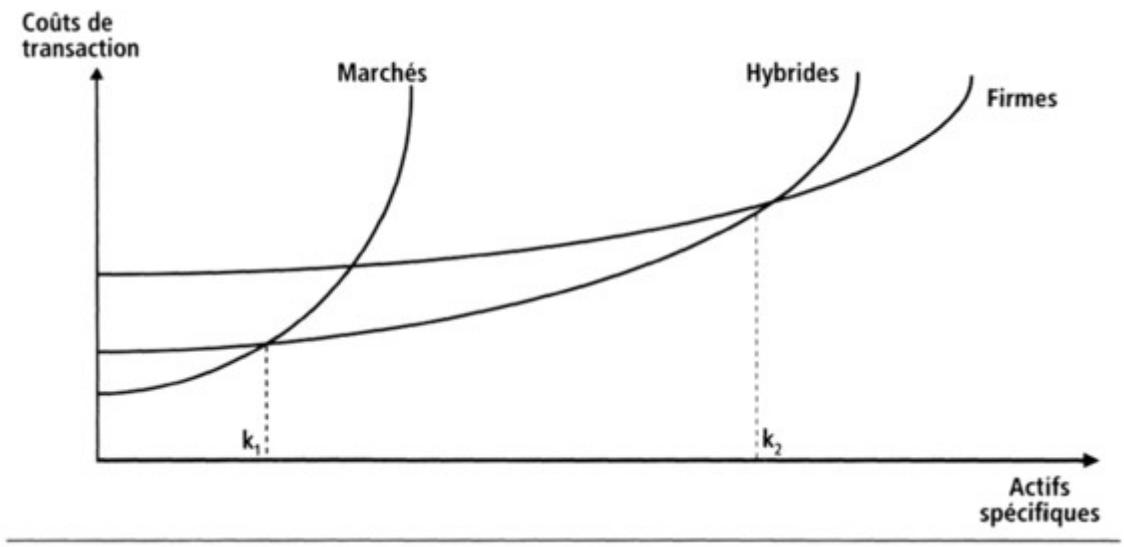

Figure 1 - Deciding between the three main organizational function of asset specificity (Williamson, 1991)

Thus, the fact that a transaction involves assets with a high degree of specificity would prevent the mechanisms for coordination of the market (competition and price system) to

compensate for the failures that may appear in contracts, by blowing up transaction costs and encouraging contractors to register in relations closer to hierarchy.

The theory of transaction costs falls within the course of the neo-institutional economics, so the study of the institutional environment there is central. Institutions delimit the scope of possible organizational alternatives and determine the effectiveness of these alternatives because they weigh on transaction costs.

Regulatory authorities have the power to significantly alter the playing field and can therefore influence the choice of governance structures that define the organizational alternatives (Ménard, 2003). The theory of transaction costs specifies that when the institutional environment puts constraints (such as contract law, which affects the costs of contracting) too strong against vertical integration, agents can react in two ways :

- by developing informal coordination mechanisms (coordination mechanisms of governance structures called hybrid[7]) that replace the formal mechanisms in the event that they would eventually be prohibited by regulation.
- by changing transaction characteristics and particularly the degree of asset specificity in order to align the governance structure with the attributes of the transaction[8].

The proof of the existence of transaction costs in transactions involving the environment has already been made in the scientific literature (Coggan et al., 2010). As part of agricultural

[7] For more details on hybrid structures refer to (Ménard, 2004).

[8] Both possibilities have been demonstrated by empirical studies on the rail sector: the work of (Palay, 1984) shows for example that the regulatory prohibition to have recourse to vertical integration pushes shippers and carriers to resort to informal arrangements for protect their specific investments. While the article (Yvrande-Billon and Ménard, 2005) shows that the operators adapt to an obligation to have recourse to short-term contracts by reducing the degree of specificity of their assets.

policies, Steele (2009) highlights three key points that make it very difficult to create management instruments aimed at internalizing the environmental externalities[9]: (1) the diffuse nature of production, (2) the great uncertainty surrounds the relationship between agricultural practices and their effects on the environment and (3) the delay between practice change and environmental effect. According to him these three factors explain the difficulty of instruments constructed on the basis of neoclassical theory to create the right price signals to improve the consideration of the environment and justifies the use of alternative approaches.

Theories and practices surrounding ecosystem services have evolved along the lines proposed by the neo-classical theory: the commodification of these (Gómez-Baggethun et al., 2010). This process was done in three steps: (1) the construction of a conversion framework of ecological functions into ecosystem services, (2) the assignation of a single exchange value for these services and (3) the union of suppliers and consumers in markets. There has been a phenomenon of "translation" of the complexity of natural capital, its internal processes and the goods and services it provides, into a variation of ecosystem services clearly identified so as to be measured and evaluated from the perspective of being traded in markets. This process of commodification is finally completed with the modification and creation of institutional rules that authorize transactions on markets as in the case of Market for Ecosystem Services (Bayon, 2004).

[9] This process is based on the adoption of an alternative reading of the article by (Coase, 1960) and follows the recommendations of Hardin : in his article entitled Tragedy of the Commons, he stated that the management regimes that lacked resources well-defined property rights made these resources vulnerable to overexploitation (Hardin, 1968).

Thus the neoclassical theory explains this phenomenon of commodification of services provided by natural capital by a commitment to internalize environmental externalities. While the theory of transaction costs analysis this process rather like the alignment of attributes of the transaction to the governance structure of the most effective response to changing institutional environment. We propose to illustrate this point through the process that led to the emergence of mitigation banking in the U.S. : we will see that considering transaction cost theory the emergence of a market of wetland leads to a decrease in the degree of specificity of natural capital.

3. Case study: the development of the mitigation banking in the US

3.1 Presentation

In 1972, the ratification of the Federal Water Pollution Control Act gave the government the power to regulate dredging or unloading (dumping) on areas with low or periodically flooded. Section 404 of the Act (always present in his 1977 version titled Clean Water Act) established a permit system: if a developer wants to fill a wetland must obtain a permit that is issued by the agency of the U.S. Army Corps of Engineers (USACE) of the concerned location. The USACE, after consultation with the regional office of the U.S. Environmental Protection Agency (USEPA) may choose either to prohibit or to allow the impact, on the condition that the developer "creates" a certain amount of wetland as compensation for the loss of natural wetlands. This is what is called the compensatory mitigation[10].

[10] The compensatory mitigation is actually the last step of what is called the mitigation sequence: this is a three step process that determines the type and level of mitigation required by Section 404 of the Clean Water Act . First, it comes to avoidance, all negative impacts on aquatic resources should be avoided if there is at least one alternative with fewer adverse impacts. Second, it comes to reduction, all the negative impacts that could not be avoided must be minimized. The third comes to compensation, all residual impacts after the application of

In the 80s, this approach was widespread, and many licenses were accompanied by an obligation to compensate. However, a series of field reports started to demonstrate that many compensation sites had in fact never been built and that those who were built were in a state of significant degradation according to ecologists' opinion (NRC, 2001) [11]. At the same time, a significant pressure from the construction industry advocated a simplification of the procedure for obtaining permits. This context led President Bush (1989-1993) to present a series of proposals grouped under the "No Net Loss of Wetlands" agenda. This agenda has attributed the failure of the mitigation sequence on the command-and-control organization of the federal administration of the CWA and has praised the introduction of market incentives for its future management (Robertson, 2004). It is besides in 1991 that appeared the first experiences of mitigation banking simultaneously in the states of Georgia, Illinois and Florida. At this time we observe among those involved in the regulation a desire to replace the so-called permittee-responsible approach, which consists of the implementation of compensation by the project developer, for an approach known as mitigation banking.

We will study the transition from the permitee-responsible system to the mitigation banking system by focusing on the consequences of this change in the organization of actors and transaction characteristics.

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steps avoidance and reduction must be compensated, the amount and quality of the compensation can never allow the compensation to substitute to steps of avoidance and reduction.

[11] For example, Kentula et al. (1992) studied the licenses granted in the states of Oregon and Washington. For 58 permits issued between 1977 and 1987 in the State of Oregon, 82 wetlands have been impacted (74 ha) while 80 were created (42 ha) which represented a 43% loss of wetlands habitat . Similarly, for 35 permits granted between 1980 and 1986 in the State of Washington, a deficit of 26% of habitat has been observed (61 ha to 45 ha created impacted). Moreover, in most cases, wetlands created were not the same as those impacted.

The theory of transaction costs requires that we focus on a transaction between two actors. Following the definition used by Williamson[12] we will consider the relationship between a developer who buys from a producer the ecosystem services necessary to offset the impact of its activity (Figure 2).

The producer of ecosystem services deploys an investment in a production tool which happens to be a wetland. This wetland has particular characteristics that determine the quantity and quality of ecosystem services it produces. The buyer seeks to acquire an "environmental gain" in terms of ecosystem services to be equivalent to the "environmental losses" related to the development project.

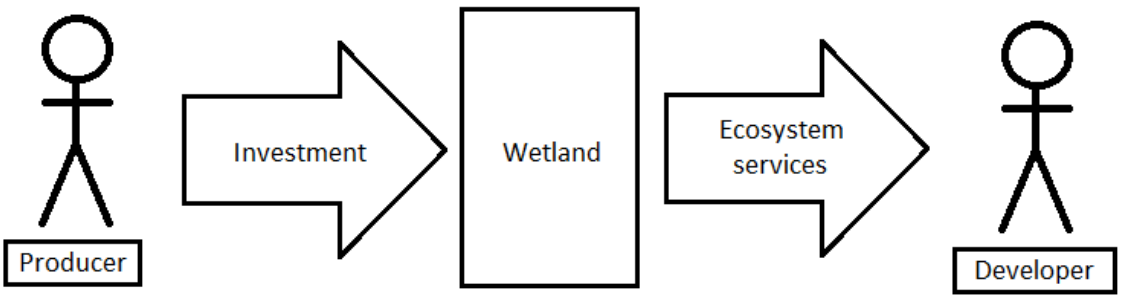

Figure 2 - Illustration of the transaction we are studying as part of mitigation banking

3.2 The system of the permitee-responsible

Under the classical scheme of the system permitee-responsible is the developer who is liable to the Corps of compensating the impact he programs through its request for permit. He must submit an application showing compliance with the mitigation sequence including, if necessary, an offset project. It is the responsibility of the developer to implement the compensation action, the regulator will control the compliance with the no net loss policy (Figure 3). Generally, the developer does not have the skills of ecological engineering

[12] "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 p1).

sufficient to establish itself the action for compensation. It will therefore usually ask a specialized engineering consulting firm to set up the compensation. The contractual relationship between the developer and the design office generally includes the characteristics of subcontracting relationships that have been studied by (Eccles, 1981), that is to say, a selection process based on negotiation contracts and short-term relationships in spite of long-term (the contractor are usually dealing with the same partners). These strategies of contracts, based on sustainable relationships, have advantages in terms of coordination, compared to the market, while avoiding the bureaucratic burden linked to integration (Ménard, 2004). This represents an advantage in operations on ecosystems that require high flexibility of the contractual relationship because of the uncertainty surrounding the results of actions.

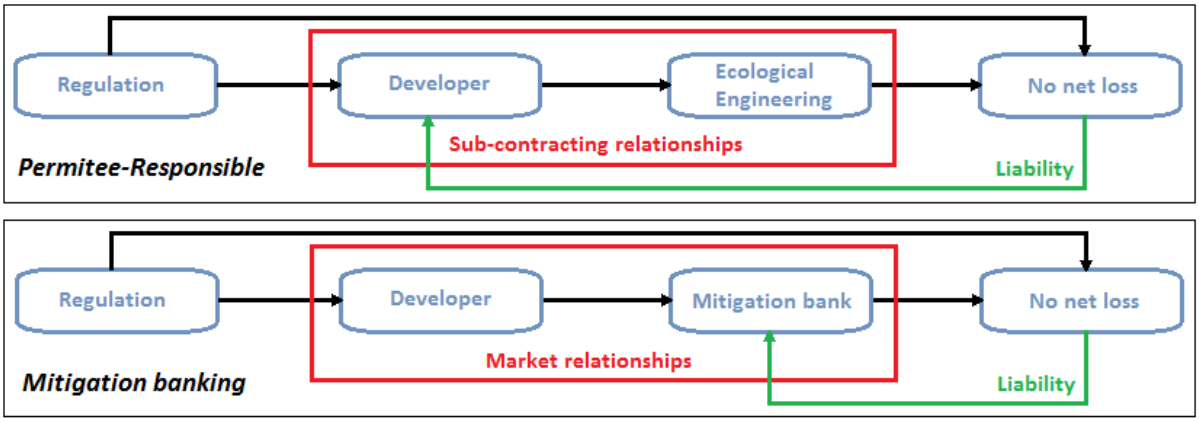

Figure 3 - Organization of the compensation system according to the approaches Mitigation Banking and Permitee-Responsible

3.3 The system of mitigation banking

The mitigation banking is a type of regulation by which, in a first step, a mitigation bank will restore a degraded wetland and create an offer for compensation. In a second step, a permit applicant may choose to obtain "wetland credits" from this company instead of producing himself its compensation wetland.

This new mode of regulation is an ecological and economic innovation. A green innovation, first with the possibility of setting up actions of compensation before the impact, since the license applicants must purchase credits produced on existing wetlands. Then with the possibility of achieving compensation "off-site"[13], such an approach enabling to break with the approach of compensation case by case which produces wetlands that do not match the originals and provide meager substitutes (Kaiser, 2001). Finally, the system of mitigation banks should help to concentrate the actions on a few sites, which should allow the regulator to deploy more resources for monitoring and enforcing quality standards (Marsh and Acker, 1992; Etchart, 1995). Furthermore, this concentration allows to set up actions at a larger scale which better match with success criteria than the smaller (Brown and Veneman, 2001). But also an economic innovation, since the mitigation banks would find themselves in competition and free to set the price of credits they sell. These two parameters provide the assurance of a price signal necessary to the establishment of a market for services provided by wetlands.

For economists, this innovation is good because it determines the value of the externalities produced by the impacts of developers. Market prices shall then draw the value of ecosystem services, prices which is therefore built on the basis of the cost of the actions needed to produce them. The effectiveness of the system relies on the principle of the no net loss since if the actions fail to compensate for the extensive damage, then the market price does not reflect the full costs to society and the market equilibrium is no longer Pareto optimal. The innovations proposed by the compensation system were therefore supposed to allay the worries of environmentalists since the systems would enhance the quality of

[13] Regulation by the permitee-responsible approach favors an approach on-site, that is to say that compensation must be implemented on the field that has been impacted.

actions, as their compliance with the impacts is at the basis of the system. However, despite the theoretical strength of the system, it appears that the mitigation banks only allow to slow the decline of biodiversity, without being a failure, the system of compensation is of modest efficacy (Burgin, 2009).

The governance structure that surrounds the relationship between the developer and the bank is now a market (Figure 3), the developer will buy the amount of credits needed to offset its impact, he no longer has to care for supervision of producer behavior. Indeed the producer's behavior is now subject to dual control. On the one hand inspection by regulation, credits are awarded by the regulator. Responsibility for the effectiveness of compensation is now based on the bank, the developer no longer has to control the quality of the product purchased. On the other hand a control by market mechanisms that allow sanctioning opportunistic behavior of producers by buying credits from its competitors. Finally for the producer, the possibility of producing ecosystem services to compensate for more than one project allows for larger operations and benefit from economies of scale.

Hallwood (2007) offers an interesting interpretation of investment in mitigation banks. He starts from the central role of regulation that sets quality standards for the investment required for the production of credits and control and penalize bankers who do not perform these investments. He shows that if the standards are demanding and control and punishment are not restrictive, then the banks will tend to neglect investment in natural capital for the production of credits.

This demonstration explains the rationale of the regulator who facing the high risk of opportunism of developers (which leads them to poorly or not compensate) and given the lack of means at his disposal to control, has chosen to encourage producers to pool their

investments on a few sites. Logic of the regulator was to strengthen controls to ensure that compensation is properly implemented.

We will now look through the literature, what were the result of this change in governance structure on the sources of transaction costs especially on the specificity of natural capital.

4. The source of transaction cost in the mitigation system

4.1. In the permitee-responsible system

A specific asset is defined as a specialized investment that cannot be redeployed to an alternative use without loss of its productive value.

The production of an environmental gain requires an investment in natural capital. Depending on the characteristics of this investment the environmental gains will differ in quality and quantity. Thus, an investment in an asset such as a wetland can be used only for a transaction to offset a certain type of environmental losses which correspond in quality and quantity to the produced gains. Wetlands are therefore specific assets and we will see that this specificity of natural capital is expressed in two dimensions: physical specificity and site specificity and that specificity of natural capital is to be linked to the specificity of human capital needed to handle it.

First, physical specificity, the term wetland refers to a wide variety of ecosystems that are very different (river, marsh, bog ...) and each type of ecosystem has characteristics and ecological functions that are specific. Within the framework of the compensation environmental equivalence between gains and losses requires a detailed definition of the target components of biodiversity and ecosystems (Quétier and Lavorel, 2011). The degree of physical specificity of natural capital is therefore determined by regulations that may

choose different approaches to determine whether two wetlands are equivalent[14]. The more the regulation will be demanding, the more the wetland deployed to provide environmental benefits will not be deployed to another transaction without cost (which may be due to a need for redesign of the wetland).

Then the specificity of site, the location of a wetland strongly influences its functioning. The environmental benefits produced by a wetland is largely dependent on the location chosen for implementation. Indeed it is impossible to consider an ecosystem regardless of what surrounds it, first because an ecosystem does not have the same function between two locations (Mitsch and Gosselink, 2000) and also because its location strongly influences ecological interactions and persistence of biodiversity (Hanski, 1998).

The issue of site specificity of natural capital is related to the quality and quantity of services provided by it, but is also related to changes in distribution of ecosystem services to the population (Flores and Thacher, 2002; Zafonte and Hampton, 2007).

Thus the environmental benefits produced by a wetland can be used to offset a loss for which the landscape dimension will be identical, it is for this reason that regulators used to prefer on-site compensation. However with the compensation on-site, once the wetland of compensation implemented it cannot be redeployed to offset an impact elsewhere without costs (costs that may result from such a compensation ratio).

The issue of asset specificity thus arises at the level of biodiversity, but also in terms of the actions performed to obtain credits. Indeed, preservation action[15] that does not allow net

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[14] See (McKenney and Kiesecker, 2009) and (Quétier and Lavorel, 2011) for a discussion of the different regulatory approaches to determine the equivalence.

[15] The Corps, which determines the shape and amount of compensation needed, recognizes four methods for compensation: (1) The restoration, which means re-establishment or rehabilitation of a wetland from the

gain of function nor gain of surface does not generate the same benefits that creation action, which allows a net gain of function and surface (Table 1), there is a need for a trading system that takes account of these differences while translating them into a single unit of exchange.

Action		Surface gain	Functional gain
Preservation		No	No
Improvement		No	Yes
Creation		Yes	Yes
Restoration	**(rehabilitation)**	No	Yes
	(re-establishment)	Yes	Yes

Tableau 1 - Correspondence between an action and its outcome in terms of net gain of surface and functions

The question of the specificity of the natural capital is confronted with questions about the specificity of the human capital necessary for the transaction. The definition of an appropriate unit of credit, the measurement of flows generated by natural capital deployed and the implementation of actions necessary to that investment require expertise in engineering and life sciences (ecology, biology, genetics). However the knowledge available in these areas are inadequate and often preferred by pragmatism, limited to the conservation of ecological communities as they are easier to evaluate than the ecosystem

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perspective of bringing a former wetland back or a degraded wetland to a level of functionality or natural history. (2) The creation, which consists of developing a wetland where none existed. (3) The improvement, which refer to actions to improve one or more functions of a wetland. (4) The preservation, which involves the permanent protection of wetlands by establishing legal mechanisms (transfer of title) or physical (preservation facilities).

services (Burgin, 2008)[16]. To avoid the problem of human asset specificity, it intentionally chose to lower the degree of specificity of the natural capital.

Specificity of assets deployed	
Physical specificity	• Complexity and diversity of components and functions of ecosystems
Site specificity	• Strong dependence of ecosystem dynamics to interactions with their wider environment
Specificity of the human capital	• Diversity of actions applicable to generate biodiversity credits and complexity of their • Diversity of knowledge to master all the features and functions of wetlands

Tableau 2 - Summary of the specificity of the assets engaged into compensation transaction

The uncertainty surrounding the transaction is the second major source of transaction costs, it can be of two kinds: first an environmental uncertainty and the other a behavioral uncertainty.

The environmental uncertainty relates to the exogenous shocks to the decisions of contractors. At the ecological level, uncertainty is an essential element of all actions taken within the management of the environment, largely due to the fact that the results of a restoration action are often different from the results expected. Indeed, ecosystems are dynamic systems constantly evolving, and despite the progress made in understanding the dynamics of succession and community composition, ecosystem restoration is rarely able to reproduce the same structure, composition or the functions of another ecosystem (Zedler and Callaway, 1999; Hilderbrand et al., 2005; Morris et al., 2006; Gibbons and Lindenmayer, 2007). Thus ecosystems may respond differently to the restoration and reach a final state different from another from the same initial conditions (Folke et al., 2004). It is therefore not certain that any action would have the intended effects on biodiversity and the destruction

[16] It should be noted that a recent change in regulation now allows to measure the allocation of offsets based on the conservation of ecosystem services (Ruhl, Salzman, and Goodman 2009).

of a wetland should be allowed once certain that the ecological objective has been reached on the compensation site, otherwise it necessarily leads to temporary losses. These temporary losses can lead to permanent damage on some populations (Walker et al., 2009), not to mention the fact that these temporal losses can become permanent if the wetland is unable to provide the services associated with gains sold (Bekessy et al., 2010).

But environmental uncertainty can also be found at the regulatory level, in this case it may be a change in the rules such as changing the criteria for equivalence.

The behavioral uncertainty comes from the opportunism of the contractors and the unpredictability of strategic behaviors that results. Contracts are constructed to anticipate these risks of strategic behavior of the agents.

In the context of the compensation, the risk of opportunism of parties is strong, as they have no interest to know precisely the environmental quality of the good they will exchange, from the time the permit is issued (Gustafsson, 1998; Kroeger and Casey, 2007). This encourages developers seeking permits to underestimate the environmental impact and producers of environmental gains to exaggerate the value of earnings generated in compensation.

When environmental uncertainty increases, it is important that contractual arrangements may be flexible enough to allow ex post adaptation to changes in the environment, without being too loose and encouraging the development of opportunistic behavior. The high specificity of the natural capital needed for the transaction coupled with the uncertainty that surrounds it, have led the actors to include their contractual relationship in governance structures closer to the hierarchy than to the market.

4.2 In the banking system

The issue of creating a market of environmental credits requires the definition of a calibrated and clearly identified unit which is the currency of exchange. For biodiversity,

there is no medium of exchange that can capture all the significant values that will be exchanged. This is as a problem of interchangeability of two units of biodiversity ready to be exchanged in a market and arises through three dimensions: type, space and time (Salzman and Ruhl, 2000).

The establishment of bank compensation required to define the unit of exchange. The answers to the problems of the type, time and space to build the exchange unit are in the system of allocation of credits and the conditions surrounding it[17].

In general, the problem of type, encountered during the creation of a unit of exchange is addressed on the level of each district through a system of classification of credits and the use of evaluation system of actions that will be applied. The problems of time related to the creation of the market is processed by the system of credits distribution for sale and the space problem by defining a service area that limits the perimeter in which a bank can sell credits for compensation. The trades of wetlands credits are all conditioned to the choice of the administrator (the Corps), which plays the role of market regulator.

We now measure the consequences of this system on the specificity of natural capital and the uncertainty surrounding the transaction.

According to neoclassical theory, one of the prerequisites for creating a market of perfect competition which can lead to an optimal distribution of resources is the homogeneity of the

[17] For example, in the Chicago district, the funds are distributed in four phases: (1) 30% of credits are issued at the same time as the request for permission to implemented the bank is done, (2) 20% are issued once the bank proves that the surface of groundwater was measured within 30 cm of the soil surface for more than two weeks between May and October, (3) 20% are issued once the banker brings evidence that all "appropriate" to native plant species have been planted and (4) the remaining 30% are issued when the banker provides evidence that the site meets a list of more specific ecological criteria (Robertson and Hayden, 2008).

products (Arrow and Debreu, 1954), which implies that it is necessary to determine an exchange unit coarse enough to be interchangeable in quality and features.

The production of wetland credits that will be traded on the market is the result of an investment in natural capital, the specificity natural capital deployed in a transaction will be determined by the definition of credits. Credits that will be exchanged must refer to all the components or functions of biodiversity, else facing the risk of losing those that would not be included in the unit of exchange (ten Kate et al., 2004). Unlike carbon credits that are constructed on the basis of a unit that is unique and quantifiable, the values of biodiversity are complex to measure, and especially the role of ecosystem services (Salzman and Ruhl, 2002). Now to run the market, the credits must allow the exchange between a producer (bank mitigation) and several consumers (permit applicant) without changing the value of credits depending on the consumer. Thus a mitigation bank must be able to compensate several impacts on different wetlands. To counter this problem the clearing system of wetlands has created a wetland classification and allows exchanges between two wetlands in the same category.

The creation of a credit system of wetlands involves that we strive to create an exchange unit of biodiversity that is relatively independent of the location of the impact from the bank that sells these credits, in effect the concentration of actions in mitigation banks excluded actions on-site. The spatial dimension is essential in the problem of interchangeability of two units of biodiversity. Solutions are proposed to integrate the particular site in the calculation of allocations to a bank using methods based on the principles of population genetics (Bruggeman et al., 2005; Scribner et al., 2005). However, such studies are proposals that find no echo in practice, the American system of mitigation banking of wetlands has chosen to restrict trade in certain geographical areas.

The issue of site specificity of the mitigation banks is related to the quality and quantity of credits that a bank can produce, but also in relation to changes in distribution of ecosystem services to individuals. The banking system of wetlands has led to a reorganization of the landscape with a "migration" of wetlands from urban to rural areas, a phenomenon criticized for being a cause of disparity and social injustice (King and Herbert, 1997; Ruhl and Salzman, 2006).

The uncertainty surrounding the mitigation banks is because they are often dependent on dynamics beyond their control and which are related to the interaction of the spheres of ecology, economics and regulatory (Robertson, 2008).

At the level of environmental uncertainty related to the manipulation of nature. Systems of habitat banking consider it possible to recreate habitats that will be a source of biodiversity, the critics often oppose the fact that future habitat units created by the restoration will not be able to replace character and functions of habitats they will compensate (Moilanen et al., 2009). Authors emphasize the potential role of the mitigation banks to avoid temporary or permanent loss of ecosystem services (Walker et al., 2009; Bekessy et al., 2010), particularly advocating for the credits being sold once the gains are actually measured. However the time required to reach maximum production gains can be expected to be long and banks need to sell credits to ensure their economic goals. Thus, credits are usually assigned in a progressive manner as and as environmental objectives are met.

At the level of uncertainty associated with environmental regulation. The regulation is central in market systems of environmental credits since it is it who determines the existence of the demand, usually by the obligation for a certain type of activity to obtain credits and the existence of the supply, by controlling the allocation of these credits (Robertson, 2008).

Economic analyzes that measure the efficiency of the system are often made from the construction of models, in which a basic assumption is a regulatory system that is stable. But in fact, regulation tends to be variable, either because it is expressed in different government scales (Robertson and Hayden, 2008), or because it is applied by individuals or agencies which may be in conflict (Hough and Robertson, 2008). Resulting in high environmental uncertainty.

The problem of regulatory uncertainty has been well illustrated in 2001 with the decision of the Supreme Court of the United States under the Solid Waste Agency trial of Northern Cook County v. U.S. Corps of Engineers (SWANCC). With this decision, the Supreme Court ended a policy of the Corps that was used to protect a type of wetlands under the CWA legislation. These wetlands called "isolated" were excluded from arbitration by the Corps under the pretext that they were not an obvious connection with navigable waters and therefore they have no place in the CWA. This decision had an immediate impact on the mitigation banking industry: for example in the Chicago area, one banker estimated that 90% of credits that he was selling were for the compensation of isolated wetlands (Robertson, 2004). These wetlands were later taken in charge at scales of more local government (including the district level) restoring the system of compensation for the latter but by causing a complete reorganization of the supply and demand. This kind of event shows that there is regulatory uncertainty around the offset markets, this kind of uncertainty typically discourages investors to engage investment of highly specificity.

Thus we observe that the establishment of bank mitigation system has been accompanied by a decrease in specificity of natural capital deployed to produce environmental gains. This decline in asset specificity raises an important question about the true nature of the goal of no net loss and justifies all the reserves that exist around the system of mitigation banking

(Walker et al., 2009). The essential issue that arises when creating a market for biodiversity, is the unit that will be used for exchanges, depending on the unit that is selected can be reach different levels of no net loss which may be associated different level of sustainability. At each level of sustainability can be associated a level of specificity of natural capital and uncertainty that repel the solutions offered by the market and therefore by the neoclassical theory, of the concept of strong sustainability.

As these criteria are explicitly taken into account by the theory of transaction costs, it is interesting to ask whether the use of this body of theory is not a theoretical basis more interesting than the neo-classical theories to study the investment in natural capital.

5. Discussion

Under the system of compensation for impacts related to development, the application of the theory of transaction costs provides an interesting interpretation of the establishment of market instruments promoted by the neoclassical theory. The commodification of ecosystem services results in a change in the institutional environment that allows players to lower the specificity of natural capital to the point defined by the unit of exchange.

In line with the position of Martinez-Alier (2002) who criticizes the change from a logic of resource conservation based on several non-monetary values to the logic of a single monetary value, converting the environment into a commodity is a process that has already been challenged by many authors (Vatn, 2000; McCauley, 2006; Kosoy and Corbera, 2010). Our goal is to participate in this debate by proposing a new reading of the problem.

The complexity and diversity of natural capital are central to the production of all the ecosystem services, the process of commodification, although he manages to stimulate investment, lowers its specificity. The theory of transaction costs allows us to identify the

levers that allow to find a significant specificity of investment, ie the institutional environment and the uncertainty surrounding the transaction.

As was shown in the case of mitigation banking, the uncertainty surrounding a transaction of ecosystem services is strong and is an important source of transaction costs, the actors of compensation should therefore seek to reduce it. We will address in particular the ecological approach adopted for the Restoration of Natural Capital, which emphasizes that investment in natural capital must take into account the resilient and self-sustaining character of ecosystems, thereby limiting the possible interventions for the restoration of natural capital, in the types of actions applicable[18] and timing of the intervention[19] (Aronson et al., 2007).

The uncertainty surrounding the transaction is not only related to the environment surrounding the transaction, but also stems from the behavior of actors. can be done Reducing this uncertainty through the development of institutions and incentives to guide investment in natural capital. This is also the approach taken by scientists of the Natural Capital Project (Daily et al., 2009). The latter highlight the importance of developing strategies to guide investment, such as the use of return on investment (Goldstein et al., 2008), which implies to control the functions of production of ecosystems and their interactions, and therefore the uncertainty surrounding them.

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[18] According to scientists of the restoration of natural capital, given the global changes that affect ecosystems, the most sustainable way to improve the provision of ecosystem services is to restore the functions and processes of self maintenance of ecosystems. Natural ecosystems are more likely to adapt to these global changes than those manmade, and more, the restoration of natural ecosystems, on a large scale, can help mitigate climate change effects (Clewell and Aronson, 2006).

[19] Species loss or alteration of misunderstood functions by impacts on the environment can not be recovered, this is why it is best to preserve or use resources in a sustainable way than to restore. Also it is better to restore as soon as possible, before the damage is too great.

We also retain the integrated approach proposed by the Resilience Alliance, which focuses on the management of socio-ecosystems. Given their unpredictable nature, this approach proposes to focus on the resilience of systems, that is to say their ability to absorb disturbances without switching to unwanted configurations (Walker et al., 2009). This approach takes into account both the environmental and behavioral uncertainty and proposes to construct strategies that feed both from the ecology, particularly the theory of adaptive cycles of ecological systems of Holling (1992) and from the economics with the importance of stakeholder involvement. The involvement of stakeholders in the process of management of natural capital is a solution for reducing the uncertainty associated with the opportunism of agentsthe management of natural capital built on approaches that promote the emergence of common management process being the approach advocated by Ostrom for the management of socio-ecosystems (Ostrom, 2007, 2009).

The institutional environment plays a central role in this loss of specificity of assets, while the emergence of markets to govern the production of ecosystem services is possible, it is primarily because the institutional environment allow it. In the framework of mitigation banking, it is the regulation that changed the institutional environment for the emergence of the market, however, the institutional environment is not limited to the regulation. In this vein, Wackernagel and Rees (1997) set out four types of structural and perceptual barriers that work against the development of investment in natural capital: (1) the social conception of nature, (2) the belief that the economic model is exactly suited to deal with ecological reality, (3) the extension of the principle of individual rationality to society as a whole and (4) the structure of modern society. These authors thus propose the use of new approaches to illustrate the importance of natural capital for the company, this is the case of accounting for

ecological footprint (Wackernagel et al., 1999) which aims to compare directly and in physical terms the production of natural capital with human consumption.

6. Conclusion

The study we propose for the evolution of compensation for impacts authorized in the United States suggests that the construction of markets for ecosystem services exchange leads to a loss of specificity of the natural capital needed to produce these services. The institutional environment is modified to encourage trading to adopt a governance structure of market type. This change in governance structure must be accompanied by a decrease in transaction costs that facilitate the coordination mechanisms offered by the market (price system). However, since the uncertainty which is an important source of transaction costs, is still strong, the other lever available to reduce transaction costs is to reduce the degree of specificity of capital deployed in the transactions.

This phenomenon is a process that is explained by the neo-institutional economics and in particular the theory of transaction costs and that justifies the interest to the teachings of the theory rather than those of the neoclassical theory.

This change in analytical framework is in line with developments observed for many ecosystem management that promote the change of governance structure, the reduction in uncertainty or behavioral modification. The lessons of the theory of transaction costs would encourage the development of these approaches but also to propose new solutions built around the particular role of regulation as encouraging the development of coordination mechanisms alternative to market. Moreover, the theory of transaction costs suggests an approach to compare the different form of governance offered by regulation and by market by focusing on asset specificity, uncertainty, or the behavior of actors in the institutional

environment. Such developments imply now to produce empirical analyzes to validate the theoretical observations in particular in the degree of asset specificity.

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