

Economic Valuation Methods: The Perception of the Accountants of the Hydroelectric Power Sector in Brazil

Métodos de Valoração Econômica: A Percepção dos Contadores do Setor de Hidrelétrica no Brasil

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Abstract

The aim of the present study was to verify how accountants perceive the electric power companies in Brazil, regarding the use of economic valuation methods for measuring environmental impacts on hydroelectric power generation. These methods would be used in the internalisation of impacts in compliance with accounting theory criteria of recognition, measurement and disclosure of relevant economic activities. This is an exploratory study based on the conclusion regarding the collected data from a questionnaire answered by accountants, who worked in the electric power sector and were members of the Brazilian Electric Power Sector Accountants Association (ABRACONEE). The research showed that 74% of respondents were accountants or accounting analysts, 92% of them believed that companies should account for (internalise) environmental impacts caused by their activities, and 75% of them believed that this task should be based on detailed and specific norms determining what should be done and when and how to do it. Despite their high level of accounting knowledge and complete familiarity with the changes determined by the Brazilian Securities Commission, respondents adopted a conservative stance in relation to the use of estimated values or those obtained in hypothetical markets. The study revealed the existence of a vast field of research that has yet to be explored by accounting in the field of environmental accounting, especially in terms of both measurement and recognition of environmental impacts caused by diverse economic activities.

Keywords: Environmental Accounting, Economic Valuation Methods and Environmental Impact.

Resumo

O objetivo do presente estudo foi verificar a percepção dos contadores das empresas de energia elétrica no Brasil, em relação à utilização de métodos de valoração econômica para medir os impactos ambientais sobre a geração de energia hidrelétrica. Estes métodos seriam usados na internalização dos impactos em conformidade com os critérios da teoria contábil de reconhecimento, mensuração e divulgação das atividades econômicas relevantes. Este é um estudo exploratório com base na conclusão sobre os dados recolhidos a partir de um questionário respondido por contadores, que trabalhavam no setor de energia elétrica e eram membros da Associação Brasileira das Empresas de Energia Elétrica (ABRACONEE). A pesquisa mostrou que 74% dos entrevistados eram contadores ou analistas de contabilidade, 92% deles acredita que as empresas devem contabilizar (internalizar) impactos ambientais causados por suas atividades, e 75% deles acredita que esta tarefa deve basear-se em normas detalhadas e específicas que determinam o que deve ser feito, quando e como fazê-lo. Apesar de seu alto nível de conhecimento de contabilidade e a completa familiaridade com as normas contábeis vigentes, os entrevistados adotaram uma postura conservadora em relação ao uso de valores estimados ou aos obtidos em mercados hipotéticos. O estudo revelou a existência de um vasto campo de investigação a ser explorado pela contabilidade no âmbito da contabilidade ambiental, especialmente em termos de mensuração e reconhecimento de impactos ambientais causados por diversas atividades econômicas.

Palavras-chave: Contabilidade Ambiental, Métodos de Avaliação Econômica e Impacto Ambiental.

1 Introduction

In recent decades, the economic activities of organisations have tested the limits of the environment; whereas the institutional pressures for sustainability and corporate social responsibility have increased (Banerjee, 2007); Therefore, making the concept of sustainable development feasible has become a high-priority issue for these organizations, whose strategic response for the aforementioned pressures was the adoption of sustainable development models.

Most of these report models requires economic activities to come to terms with the preservation of the environmental base and to seek a more complete integration of economic and environmental factors, drastically curtailing processes involving the erosion and acidification of soil, the degradation of hydric resources and the destruction of native forests and loss of biodiversity.

The internalisation of these costs associated with the degradation of the resource base in the economic process requires the quantification of the values of the services provided by nature that have been lost through degradation, and it is at this stage that economic valuation methods should be applied. In most cases, these externalities are currently not valued, not because of a lack of value, but because current measurement systems find it difficult to quantify their value (Cook, 2009). As a matter of fact, the fields of environmental economics and ecological economics have been developed in order to take into account externalities, which were traditionally excluded from classical market-base economics (Marten, 2012), and the results of these academic researches have become the basis of corporate reports and performance

As there is just few studies about impacts on environmental in ELETROBRÁS (Centrais Elétricas Brasileiras), a Brazilian electric company ranked first among the country's

holding companies in terms of gross revenue, has been focusing on the environmental impact of power generation activities and sponsored a study entitled, “Evaluation of Environmental Liabilities”, in which the goal was to provide an evaluation of the potential risks to the business. The aim of the study, developed by Tolmasquim et al. (2000), was to provide an evaluation of potential risks to the business, and the document is considered to be the most important document yet produced regarding the evaluation of environmental impacts in the Brazilian power generation sector. For this reason, the document was chosen to underpin the development of this paper.

Based upon studies that have analyzed the diverse environmental impacts caused by the power sector, Tolmasquim *et al.* (2000) proposed relevant economic valuation methodologies to value these impacts. The study group selected and identified the impacts of the Brazilian hydro-electric power generation sector based on the Reference Document for the Budgeting of Socio-Environmental Programs, for power generation plants, prepared in 1994 by the Electricity Sector Environmental Activities Organising Committee (COMASE)ⁱ. The authors subsequently have proposed valuation methods, which would be more appropriate for each kind of impact. Nevertheless, there are a limitation in this study, the benefits obtained from the creation of reservoirs were not considered in the study, as they did not represent a risk to the business, that is, a liability.

As stated by Gray *et al.* (1993), accounting should cover the analysis of costs in key areas, such as power, refuse and environmental protection. The Club of Rome recognises that a major necessary connecting factor in the world economy is the need to calculate environmental degradation in the widest sense within the system of national accounts (Dieren, 1995).

The research problem discussed in this study involves the issue of how to value these environmental liabilities economically, by using methods that can be incorporated into accounting, as well as deciding what methods should be used to internalise these liabilities.

Despite the importance of the theme and the various research problems that have appeared, few studies have been made of valuation methods and accounting. For this reason, it was decided to investigate whether accountants of large companies in Brazil’s electric power sector were familiar with the well-known methods used by environmental economists and engineers.

Relating the environmental impacts listed by the COMASE to the valuation methods proposed by Tolmasquim *et al.* (2000), we have designed this study in order to apprehend the accountants’ perceptions on companies, which operate in the Brazilian electric power sector, regarding the following: the use of economic valuation methods proposed by environmental economics for measuring environmental impacts in hydroelectric power generation; and regarding the possibility of incorporating them in compliance with the criteria of accounting and the recognition, measurement and disclosure of relevant economic activities.

To achieve this objective, a questionnaire was prepared and given to accountants in the electric power sector who were members of the Brazilian Electric Power Sector Accountants Association (ABRACONEE)ⁱⁱ. The study focused on the hydroelectric power sector, due to its considerable and diverse impacts on Brazil’s ecosystem (water reservoirs, forests, ecosystems, natural resources) as well as – by Brazilian standards - its high degree of organisation and transparency.

This paper has been divided in five sections, including this introduction. In the next one, we will describe our methodological procedures; then we will present the theoretical framework, which we will use to discuss our empirical results. In the fourth section, we acquaint our empirical findings, which are discussed in fifth the last section.

2 Methodological Procedures

This study has been designed upon Heidegger's phenomenology, a philosophical and also methodological approach, which seeks to understand and interpret the experiences of each individual to from their particular perspectives (Heiddeger, xxx).

We have opted for a script compatible with the focused, semi - structured interview (Goldenber, 2000), and we have also taken into consideration Rubin and Rubin's suggestions to select subjects that know the cultural arena, situation or experience to be studied, and are willing to talk (Rubin; Rubin, 1995)..

A qualitative approach was justified in the present study by the fact that very little information was available in the accounting sphere regarding the subject to be researched. This lack of information made it necessary to explore people's knowledge, which they formed based on their experiences, everyday knowledge or perceptions.

As an exploratory research, the objective of the present study was for accountants to achieve a greater degree of familiarity with the problem, thus making the problem clearer so that ideas could be improved and intuitions could be discovered. The planning of this research was therefore quite flexible to allow the most varied aspects of the subject under study to be considered.

A way of verifying the perception of a specific group that one intends to study is through the questioning and subsequent analysis of their behaviour. The specific objectives of the study in using a questionnaire were as follows:

- a) Characterise respondents' profiles and their levels of accounting knowledge and professional experience;
- b) Verify accountants' knowledge of accounting and the changes that had occurred in the field in recent years;
- c) Verify accountants' levels of knowledge regarding the use of economic valuation methods for measuring environmental impacts caused by the hydroelectric sector; and
- d) Compare accountants' choices with the methodologies proposed by environmental economics.

The research sample was chosen randomly from accountants who worked in Brazil's electric power sector. A total of 75 associated companies received the questionnaire, which was posted at the "Encuestafacil" website. A link to this website was included in the email sent by ABRACONEE's administration inviting the companies to take part in the survey. The survey remained available to respondents from May 11 to July 8, 2010.

A total of 43 accountants accessed the questionnaire through the link included in the email, but only 31 responded during the period it was available at the website; this gave a response rate of 41% of the population. None of the respondents was identified during the filling out of the questionnaire, thus guaranteeing confidentiality and the anonymity of respondents.

The first part of the questionnaire focused on identifying the respondents' profiles regarding their academic training, field of work, number of years working in the area and company function or position. Of the total number of respondents (31), 42% had a university degree, 48% had taken some kind of *lato sensu* post-graduate course (specialisation), and 10% (3) had a master's degree; no respondents had obtained a PhD.

A total of 26% of the companies the respondents worked at belonged to the electric power generation sector, 13% belonged to the electric power transmission sector, 51% belonged to the electric power distribution sector and 10% belonged to a combination of the three sectors (generation and transmission – 2; generation, transmission and distribution – 1).

In terms of the number of years spent working in the same area of activity, none of the respondents had less than 1 year of professional experience. A total of 19% of respondents had between 1 and 5 years of professional experience, 29% had between 5 and 10 years of professional experience and 52% had more than 10 years of experience. Thus, 80.65% of respondents had more than 5 years of experience in the power sector, with an average of 3.323 years of experience, with a confidence interval of 95%, a standard deviation of 0.791 and a sampling error of 0.142.

The respondents' position profiles showed that 74% were accountants or accounting analysts, 16% were superintendents, coordinators or directors, 6.5% were accounting technicians and 3.5%, that is only one, was an environment manager.

The second part of the questionnaire, which dealt with accounting knowledge, sought to discover electric power sector accountants' perceptions – through a dichotomic (yes/no) answer with an option for comments – of the relationship between environmental impact and accounting.

A total of 92% of the 24 accountants that answered this part of the questionnaire believed that companies should account for (internalise) environmental impacts caused by their activities, and 8% believed that they should not. 23% of the respondents do not response this question.

Replying to the question as to whether the company they worked at should account for (internalise) the environmental impacts caused by their activities, supported in this task by a detailed and specific norm determining what, when and how things should be done, 75% replied yes and 21% replied no. Of the 31 respondents, 7, did not answer the question, leading to a non-response rate of 23%.

When asked whether support for accounting environmental impacts should be constituted by a broader norm that provided the tools but left it to them to define the option that best fit their company's needs, 68% answered yes, and 27% answered no. The remaining 5% chose to give another answer, declaring that "even if they were broader, the norms should be clear and objective". In this case, 29% did not answer the question.

Supposing that the valuation methods proposed by environmental economists were recognised and used by to measure assets and liabilities, 77% of respondents said they would include the results in the accounts, and 9% of respondents said they would not do so. The 'other' reply option was used by 14% of respondents who suggested the implementation of "extra-accounting monitoring" or that the measurement should be undertaken "in agreement with company technicians, specialised bodies and in accordance with basic rules and the results of university research, covering the requirements of international standards of control". Additionally, 29% of respondents did not reply to this question.

The next question was as follows: supposing that the valuation methods proposed by environmental economists were recognised and used to measure assets and liabilities, how would disclosure the values that resulted from the use of these methods? Of the respondents, 86% agreed that they would disclosure in the Notes, and 14% said that they would not. In this case, 29% of the accountants did not reply. One comment written in the optional "space open for comments related to the previous question" was as follows: "if it is not required to be divulged, it is not necessary to do so; what is important is to disclosure data for analyses and comparisons".

The aim of the third part of the questionnaire was to verify accountants' knowledge regarding the *environmental impact* and *economic valuation method* applicable for the valuation of each impact. The alternatives that respondents could choose from were taken from literature that was specific to each situation. The questions referred to environmental impacts caused by the construction and use of a hydro-electric power generation plant.

Several ways of calculating the value of these several impacts were proposed using different economic valuation methods.

Five versions of the questionnaire were developed. Pre-test was realized in each one of these with professionals of the same sector, they don't respond the final version. It was divided in part one – profile of the respondents, part two – the accounting knowledge and part three offer them a list about possible impacts on power sector, a list with a description about several methods to evaluate each specific impact. The respondents needed to choose/link each one of them dichotomic (yes/no) answer (with an option for comments) – of the relationship between environmental impact and accounting

3 The Main Environmental Externalities Caused by Hydroelectric Power Generation

For several years, the Brazilian power sector has been considering environmental variables in its energy planning as a management tool for decision-making. Recently, with the advent of “globalisation” and the increase in worldwide economic transactions, such as acquisitions, privatisations, joint ventures and foreign capital investments, it has become increasingly important to evaluate environmental liabilities involved in business; such liabilities should be valued according to the peculiarities of the undertaking analysed, and their location may represent a high risk to the business (ELETROBRÁS, 2000, p.11).

The selection and identification of impacts used in this study were based on the References Document for the Budgeting of Socio-Environmental Programs, prepared for power generation plants in 1994 by the Electricity Sector Environmental Activity Organising Committee (COMASE). The COMASE set up an Environmental Costs Work Group that proposed a concept of socio-environmental costs that fit the characteristics of the Brazilian power sector.

Based on the systematisation of aspects and impacts, externalities were defined that were appropriate for valuation and incorporation into the power sector's long-term planning.

The externalities complied with the following criteria: their degree of importance for the sustainable development of the country's economy; the difficulty in eliminating externalities through the adoption of control, compensation or mitigation measures; and the feasibility of valuation's application in long-term planning at a “non-prohibitive cost” (TOLMASQUIM, 2000).

To assess the value of degradation costs in long-term plans deriving from thermo-electric power and hydro-electric power generation activities, the following stages were followed:

- 1) Systematic characterisation of the impact caused by each thermo-electric and hydro-electric power generation activity.
- 2) Identification of economic effects deriving from the environmental impacts characterised during stages not usually controlled, mitigated or compensated by the power/electricity sector.
- 3) Definition of the categories of thermo-electric and hydro-electric power generation activities appropriate for identifying and incorporating the degradation cost into long-term planning of the power sector.
- 4) Selection of the degradation costs for valuation and inclusion in long-term planning of the power sector of the categories defined in each stage, complying with the following criteria:
 - a) Relevance for the sustainable economic development of the country;
 - b) Difficulty in eliminating environmental externalities through the implementation of control, compensation or mitigation measures; and

- c) Feasibility of the inclusion of valuation in long-term planning at non-prohibitive costs;
- 5) Suggested use of the most appropriate valuation techniques to obtain the degradation cost selected (TOLMASQUIM *et al.*, 2001).

The following stand out among the impacts caused by hydro-electric power generation and should be valued and considered in long-term planning by the power sector:

- a) The damage caused to **biodiversity in animal and vegetal species**, which includes the variety of animal and vegetal species that exist in a specific region, including genetic diversity, the communities that compose them and their preservation, and the loss of genetic patrimony, thus causing profound changes in the Brazilian ecosystem;
- b) The damage caused to **historical and cultural resources**, which consists of the areas where geological exploration is occurring to discover cultural resources and/or archaeological sites of peoples who used to inhabit the region;
- c) The damage caused to **extractive timber and non-timber products**. Such timber exist in forests that are directly affected by the flooding of areas for the creation of reservoirs and the establishment of hydraulic infrastructure, which influences land use, leading to a reduction in the surface covered by natural vegetation relative to that covered by commercially exploited species;
- d) The damage caused to **vegetal species and medicinal plants**, which contribute to the development of new drugs and encompass a diversity of existing species, for example in the Amazon, making it possible to discover new genetic resources (bio-prospection) in tropical area forests and thus potentially leading to the development of new pharmaceutical products and agricultural seeds;
- e) The damage caused to **biodiversity in ecosystemic functions**, in the case of carbon capture, which occurs due to the replacement of natural vegetation cover of an ecosystem, resulting from changes in the amount of biomass in relation to the original amount, and leading to a net emission of carbon dioxide into the atmosphere; here, the reduction in the vegetation cover reduces the incorporation of carbon dioxide by the vegetal biomass (reduces carbon capture);
- f) The loss of benefits caused by the construction of a power plant due to **soil erosion** – this includes the deforestation and flooding of areas to create a reservoir, paired with natural processes, which accelerates soil erosion and results in the silting up of the reservoir and the ensuing reduction of its water storage capacity, thus affecting the economic benefits that should be generated; and
- g) Damage caused to **mineral resources** – considers the loss of metallic and non-metallic mineral resources due to the flooding of the areas for reservoirs and construction of hydroelectric power plants.

4 Economic Valuation Methods

The task of economically valuing an environmental resource involves the determination of how the welfare of individuals is affected for better or worse when changes occur in the quantity and quality of environmental goods and services, both when in use and when not in use.

Each method used in environmental economics has its limitations in terms of value coverage, which is linked to the degree of methodological sophistication required. These limitations depend on the hypotheses adopted regarding the behaviour of individuals related to the effects of the consumption of the environmental good and to other sectors of the

economy. Therefore, the adoption of each method will depend of the valuation’s objective, the hypotheses adopted, the availability of data and the knowledge of the ecological dynamics of the object to be valued.

Motta (1998) divides economic valuation methods into production function methods (marginal productivity methods and substitute good markets) and demand function methods (complementary good market methods: hedonic price and travel cost methods and the contingent valuation method).

The author describes the first group as methods that use market prices of goods or services to estimate the economic value of an environmental resource, considering the environmental resource as an input or substitute of a private good or service. Demand function methods, according to the author, assume that the variation in the availability of an environmental resource affects economic agents’ willingness to pay for or accept a resource or its private complementary good.

Similarly, Dixon *et al.* (1994) divide valuation method approaches into objective valuation approaches (OVA) and subjective valuation approaches (SVA). OVA are based on physical relationships that formally describe cause-and-effect relations and provide objective measures of damages that result from various causes. SVA, on the other hand, are based on a more subjective assessment of possible damage, expressed or revealed in hypothetical or real market behaviour. That is, SVA are based on expressed or revealed preferences and are directly related to individuals’ utility functions.

Table 1: Description, examples and economics valuation methods’ applicability

| Valuation Methods | Description | Examples | Applicability |
|---|---|---|---|
| Changes in productivity (marginal productivity method) | Bases for measurement are direct extensions of traditional benefit-cost analysis. This approach is based on neoclassical welfare economics and the determination of social welfare. | Continued logging with consequent damage to a Bay’s ecosystem and resulting losses of fishery and tourism income (the analysis examine the changes in production of the trees harvest, fish caught, and tourists visiting). | Evaluation of the alternatives of conservation and conversion of mangroves; estimate the economic costs of soil erosion. |
| Opportunity cost | Based on the concept that the cost of using resources for unpriced or unmarketed purposes can be estimated by using the forgone income from other uses of the resource as a proxy. | Preserving land for a national park rather than harvesting its trees for timber. | Evaluation of the alternatives to damming a canyon for the generation of hydro-electric power or keeping the unique area of wilderness. |
| Travel Cost | Based on that observed behaviour can be used to derive a demand curve and to estimate a value for an unpriced environmental good by treating travel cost as a surrogate for variable admission prices. | Determine the consumers’ willingness to pay, up to the point at which no one from a given zone would visit a park. | Estimate the value of cultural and historical sites threatened by development projects. |
| Contingent Valuation | Based on a hypothetical valuation when markets for environmental goods do not exist or there are no alternatives markets. The technique involves the direct questioning of consumers to determinate how they would react to certain situations. | Bidding games; Take-it-or-leave-it experiments; Trade-off games; Cost-less choice; and the Delphi Technique. | Willingness to pay or willingness to accept of consumers for ambient surface water quality improvements in a specific region. |

| | | | |
|---|---|--|--|
| <p>Hedonic Approaches - Property and other land-value approaches</p> | <p>Based on an alternative to neoclassical consumer theory in which a class of differentiated products is completely described by an array of objectively measurable characteristics. Goods and services consist of a bundle of attributes that they contain, and prices reflect these differences.</p> | <p>The value of a house is affected by many variables including its size, construction and location, and the quality of its environment.</p> | <p>Analysis of the effect of air pollution on housing values in some industrial region or the study of water quality problems in a lake.</p> |
|---|---|--|--|

Source: Adapted from Dixon, *et al*, 1994.

Table 1 presents a summary of the approaches, examples and applicability of environmental measurement methods used in this study. It should be noted that the source indicated presents another set of valuation methods that are not applicable to environmental impacts related to the Brazilian hydroelectric power sector.

5 Findings

The research questionnaire was divided into three parts. The first part contained questions that sought to define respondents' profiles, the second was designed to determine accountants' knowledge of accounting, and the third was aimed at verifying accountants' knowledge regarding *environmental impacts* and the *economic valuation method* applicable for the valuation of each impact presented. The results obtained are presented below.

Based on published descriptions of valuation methods, the research sought to verify accountants' perceptions through their choice of the methods that would be most appropriate for calculating the value of the impacts listed. This part contained alternatives with only one possible answer, but the respondents could make comments.

Regarding damage caused to the biodiversity (vegetal and animal species) of the region and the area surrounding the place where a power generation plant would be installed, 53% of respondents would use the hedonic price method, and 20% of the respondents would use the Contingent Valuation Method to calculate the value of the impact.

Table 2: Damage caused to biodiversity (vegetal and animal species)

| Alternatives | Answers |
|--|---------|
| ✓ Would base calculations on variations in the market price of the property, considering its general characteristics, including environmental ones, aesthetic issues, location and other aspects that drive the value of a property. | 53% |
| ✓ Would use hypothetical market values obtained through a questionnaire that show the willingness of the population involved to pay for or receive a certain level of change or environmental improvements. | 20% |
| ✓ Would not know what to choose. | 27% |
| ✓ Other answer. | 0% |
| ✓ Did not reply to the questionnaire (out of 31 respondents). | 52% |

Source: Prepared by the authors.

In situations where damage would be caused to historical and cultural goods, given the example of a church that was more than 200 years old and had a significant collection of gold-leaf sculptures and rare books, 13% of respondents chose the contingent valuation method, and 53% of the respondents chose the hedonic price method.

Table 3: Damage caused to historical and cultural goods

| Alternatives | Answers |
|--|---------|
| ✓ Seek to value the impact of the construction of a power generation plant according to the preferences revealed by surveys, estimating the price that individuals would be willing to pay to preserve the region. | 13% |
| ✓ Base calculations on market prices of the property, considering its general characteristics, aesthetical issues, location and all other aspects that make up the value of a property. | 53% |
| ✓ Would not know what to choose. | 27% |
| ✓ Other answer. | 7% |
| ✓ Did not reply to the questionnaire (out of 31 respondents). | 52% |

Source: Prepared by the authors.

In the case of impacts on timber and non-timber extractive products, which would no longer be produced when a power generation plant was constructed, 60% of accountants thought that the economic valuation method that would best measure these impacts would be the marginal productivity method, whereas 20% of the respondents opted for the marginal cost method.

Table 4: Problems caused in the case of timber and non-timber extractive products that will no longer be produced

| Alternatives | Answers |
|--|---------|
| ✓ Determine the value based on the contribution of trees as inputs or factors of production, that is, using the market value of timber and its production over time. | 60% |
| ✓ Consists of evaluating the cost and benefits of preserving the existing resource at the site where the plant will be built, that is, constitutes an economically based decision as to whether or not a forest should be preserved. | 20% |
| ✓ Would not know what to choose. | 20% |
| ✓ Other answer. | 0% |
| ✓ Did not reply to the questionnaire (out of 31 respondents). | 52% |

Source: Prepared by the authors.

Regarding the damage caused to vegetal species and medicinal plants that contribute to the development of new drugs, the best alternative, according to 29% of the respondents, would be the opportunity cost method. Using the market value of products obtained through bio-prospection to discover new drugs was indicated as the best alternative by 29% of the respondents.

Table 5: Damage caused to vegetal species and medicinal plants that contribute to the development of new drugs

| Alternatives | Answers |
|---|---------|
| ✓ Use an evaluation of the cost of preserving existing natural resources at the place where the plant will be built, through a cost-benefit analysis; that is, based on the cost of preserving the region or establishing a power generation plant. | 29% |
| ✓ Use the market value of products obtained through bio-prospection (discovery of new drugs). | 29% |
| ✓ Would not know what to choose. | 42% |
| ✓ Other answer: | 0% |
| ✓ Did not reply to the questionnaire (out of 31 respondents). | 55% |

Source: Prepared by the authors.

In situations where damage would be caused to biodiversity in eco-systemic functions, in the case of carbon capture, 21% would use the opportunity cost method, but 36% of the respondents would use the opportunity cost of carbon capture in forests that would be converted.

Table 6: Damage caused to biodiversity in eco-systemic functions – carbon capture

| Alternatives | Answers |
|---|---------|
| ✓ Use the valuation method that evaluates the cost of preserving natural resources that exist in the region through a cost-benefit analysis; that is, based on the cost of preserving the region or setting up a plant there. | 21% |
| ✓ Use the opportunity cost of carbon capture in forests that will be converted; that is, calculate the economic return of activities in the converted forest. | 36% |
| ✓ Would not know what to choose. | 43% |
| ✓ Other answer. | 0% |
| ✓ Did not reply to the questionnaire (out of 31 respondents). | 55% |

Source: Prepared by the authors.

For the loss of benefits due to soil erosion caused by the installation of a plant, 36% of the respondents chose the contingent valuation method in the case of, and 36% of the respondents chose the marginal productivity method.

Table 7: Loss of benefits caused by the installation of a plant due to soil erosion

| Alternatives | Answers |
|---|---------|
| ✓ Seek to measure the impact on individuals' welfare, applying a questionnaire that aims at discovering whether they prefer the area's preservation or the construction of a power plant, estimating the price they would be willing to pay for preservation. | 36% |
| ✓ The valuation is based on the contribution of a specific natural resource or the land as a factor of production for obtaining any kind of product. | 36% |
| ✓ Would not know what to choose. | 29% |
| ✓ Other answer: | 0% |
| ✓ Did not reply to the questionnaire (out of 31 respondents). | 55% |

Source: Prepared by the authors.

For damage caused to mineral resources located in regions where a power generation plant would be installed, 46% of the respondents would use opportunity cost, and 31% would use the value of the cost in use of exhaustible mineral resources.

Table 8: Damage caused to mineral resources

| Alternatives | Answers |
|--|---------|
| ✓ Would base the evaluation on the cost of preserving existing mineral resource assets, through a cost-benefit analysis; that is, on the cost of preserving the site or setting up a power generation plant. | 46% |
| ✓ Would base the evaluation on the cost in use of exhaustible mineral resources. | 31% |
| ✓ Would not know what to choose. | 23% |
| ✓ Other answer. | 0% |
| ✓ Did not reply to the questionnaire (out of 31 respondents). | 55% |

Source: Prepared by the authors.

6 Discussion and Conclusions

Regarding respondents' profiles, 52% had more than 10 years of professional experience in the power sector and 58% had a specialisation diploma or a Master's degree; 90% of the latter held a position as an accountant, analyst or head/coordinator of their company's accounting sector. All of this information is important, as it characterised a profile of qualified respondents who would be expected to have a good knowledge of accounting and the changes that have occurred in the field in recent years.

Despite having a good knowledge of accounting (due to their training) and being completely familiar with the changes made by the Brazilian Securities Commission, the

respondents revealed through their answers a conservative stance. This statement is based on the fact that, when questioned about the application of valuation methods, the respondents tended to choose the alternative that contained the expression “market prices”. When there was no indication of the use of market prices, the answers were evenly divided; there was a high tendency to choose the “would not know what to choose” alternative when the choice did not fall on any of the items proposed. That is, respondents found it difficult to choose values based on estimates. It is important to acknowledge that accountants have a tendency to place greater faith in values obtained using historic cost or values obtained in the market to measure the value of assets and liabilities.

Another tendency observed in relation to accounting was that when the respondents were questioned as to whether the norm should be detailed or specific – which are mutually exclusive answers - the answers highlighted the fact that accountants find it difficult to choose between procedures defined by the Brazilian accounting norms that existed before the convergence process and the current IASB (International Accounting Standard Board) model, at least in relation to the object of this research. A total of 75% of respondents chose the first option, whereas 68% chose the second. This result indicates that some respondents chose both options. This part of the questionnaire had an abstention rate of between 23 and 29%, showing that the accountants’ knowledge of environmental impact valuation issues was sketchy.

It is also clear that although there are specific studies of the valuation of environmental impacts in the power sector, some of which have been financed by the sector’s largest company (Eletrobrás), accountants were not familiar with them. This statement can be inferred from the fact that in the case of questions that related environmental impacts to valuation methods, a very high proportion of respondents did not choose any alternative (52 to 58%), not even “would not know what to choose”.

Table 9 below compares the valuation methods proposed by Tolmasquim *et al.* (2000) and the methods chosen by accountants who took part in the present research for valuing environmental impacts caused by the hydroelectric power sector. The first column shows the damage caused to the environment by the installation or functioning of a hydroelectric power plant. The second column contains the valuation methods proposed by Tolmasquim *et al.* (2000) for each kind of environmental impact. The third column shows the percentage of accountants who chose the proposals formulated by Tolmasquim *et al.* (2000). The fourth column presents the methods chosen by the accountants, and the fifth column presents a description of the accountants’ perceptions.

Table 9: Comparison between the valuation methods proposed by Tolmasquim et al. (2000) and the methods chosen by accountants for valuing environmental impacts caused by the hydroelectric power sector

| Environmental Impact | Methods Proposed by Environmental Economics | Accountants’ Perception of the Proposal | Method Chosen by the Accountants | Perception of Accountants in Answers |
|--|--|--|---|---|
| Damage caused to biodiversity – animal and vegetal species. | Contingent Valuation. | 20% chose the method proposed. | Hedonic price method - 53% of answers. | Different from the methods proposed by Environmental Economics. |
| Damage caused to historical and cultural resources | Contingent Valuation. | 13% chose the method proposed. | Hedonic price method - 53% of answers. | Different from the methods proposed by Environmental Economics. |
| Damage caused to extractive timber and non- | Marginal Productivity. | 60% chose the method proposed. | Marginal Productivity - 60% of answers. | Equal to the methods proposed by Environmental |

| | | | | |
|--|--|--------------------------------|--|---|
| timber products | | | | Economics. |
| Damage caused to vegetal species and medicinal plants that contribute to the development of new drugs | Market value of the products obtained through bio-prospection. | 29% chose the method proposed. | Would not know what to choose - 43% of answers. | Different from the methods proposed by Environmental Economics. |
| Damage caused to biodiversity in eco-systemic functions, in the case of carbon capture | Environmental (opportunity) cost incurred by carbon capture from the atmosphere. | 36% chose the method proposed. | Would not know what to choose - 43% of answers. | Different from the methods proposed by Environmental Economics. |
| Loss of benefits caused by the installation of a power plant due to soil erosion | Marginal Productivity. | 36% chose the method proposed. | Marginal Productivity and Contingent Valuation - 36% each. | Partially equal to the methods proposed by Environmental Economics. |
| Damage caused to mineral resources | Value of Cost in Use of Exhaustible Resources. | 31% chose the method proposed. | Opportunity Cost - 46% of answers. | Different from the methods proposed by Environmental Economics. |

Source: Prepared by the authors.

The aim of the above table is to simplify the recorded behaviours of accountants when challenged to answer questions about the relation between impacts and the valuation methods proposed. The first fact to be highlighted is that 58% of respondents did not choose the alternatives proposed, which shows a certain lack of knowledge of the subject, given that every question presented a “would not know how to choose” option.

In the case of damage caused to the biodiversity of animal and vegetal species, the method chosen by the accountants to value these impacts was different from the one proposed by the Eletrobrás-sponsored study. A total of 53% of the accountants opted for the hedonic price method (which uses the market price of property), whereas 20% chose the method proposed by Tolmasquim (2000). It should be emphasised that the choice expressed by 20% of the respondents could be attributed to their knowledge of the subject. However, this was not confirmed in the following questions, as the absolute number of accountants who chose the proposal put forward by Tolmasquim *et al.* (2000) was different for these following situations.

In the case of damage caused to historical and cultural resources, the method chosen to value these impacts by the accountants was also different from the one proposed by Tolmasquim. A total of 53% of the accountants opted for the hedonic price method (uses the market price of real estate), and 13% chose the contingent valuation method. The use of terms such as “hypothetical market values”, the results of preferences revealed during research, estimating the price that individuals would be prepared to pay for the region’s preservation may be attributed to accountants’ tendencies not to choose methods suggested by environmental economists, which corroborates the perception that the accountants have a conservative tendency regarding the use of hypotheses and estimates for measuring assets and liabilities.

In the case of damage caused to extractive timber and non-timber products, the method chosen by the accountants to value these impacts was the same as that proposed by Tolmasquim. A total of 60% of the accountants who answered this question chose the marginal productivity method to value this impact. As this was the only “correct” option in

the comparisons made, it can be inferred that this result was due to the fact the alternative contained “the market value of timber and of its production over time” as a description of the method to be used.

For the damage caused to vegetal species and medicinal plants that contribute to the development of new drugs, the method chosen by the accountants to value these impacts was once again different from the method proposed by Tolmasquim. A total of 29% of the accountants opted for the method that uses the market value of the products obtained through bio-prospection, 43% of the respondents declared that they did not know what to opt for, and none of them chose another alternative method or showed any knowledge of the subject.

As for the damage caused to biodiversity in eco-systemic functions, in the case of carbon capture, the method chosen by the accountants to value these impacts was different from the one proposed in the Tolmasquim study. A total of 36% of the accountants chose the value of the environmental (opportunity) cost incurred by the capture of carbon from the atmosphere, 43% of the accountants declared that they did not know what to opt for and none of them chose another alternative method or showed only a few knowledge of the subject.

In the case of the loss of benefits caused by the installation of a power plant due to soil erosion, the method chosen by the accountants was partially equal to the method proposed in the cited study. A total of 36% of the accountants chose the method proposed, the marginal productivity method, and 36% chose the contingent valuation method. This result was probably because the questions contained no terms that could bias the answer.

Finally, in the case of damage caused to mineral resources, the method chosen by the accountants to value these impacts was different from the method proposed by Tolmasquim, repeating the tendency of other results. A total of 31% opted to use the method that considers the cost in use of exhaustible resources, and the opportunity cost method was chosen by 46% of the participants.

The aim of the present exploratory and qualitative study was to verify the perception of Brazilian accountants who work in the power sector regarding the use of economic valuation methods for measuring the environmental impacts caused by the hydro-electric power production activity. The research used a questionnaire to discover whether accountants - if they had the values resulting from the use of these methods - would be willing to internalise, that is, account for environmental impacts following the criteria of disclosure, measurement and recognition of assets and liabilities available in accounting theory.

Furthermore, the study sought to verify accountants' perceptions regarding the choice of methods that were more appropriate for valuing the impacts caused by hydroelectric power activities that were defined by the studies undertaken by the power sector's Environmental Activities Organising Committee (COMASE). The study presented a series of impacts and one benefit (which was not used for the purposes of this study, as it would constitute an environmental asset if accounted for by the sector's companies): damage caused to biodiversity – vegetal and animal species; the damage caused to historical and cultural resources; the damage caused to extractive timber and non-timber products; damage caused to vegetal species and medicinal plants that contribute to the development of new drugs; damage caused to biodiversity in eco-systemic functions, in the case of carbon capture; the loss of benefits caused by the installation of a power plant due to soil erosion; and the damage caused to mineral resources.

It was perceived, for example, that there was a tendency on the part of the respondents to choose alternatives that contained the expression “market price”. In nearly all of the methods proposed by the environmental economics literature for valuing the impacts defined by the COMASE, the perceptions of accountants were different from the methods proposed (in the case of five of the seven impacts). Perceptions that were equal or partially equal to the

methods proposed occurred in two of the seven impacts presented (in these cases, marginal productivity, which uses market prices, was the method proposed).

The results of the research show that accountants who work in the electric power sector have only a very superficial knowledge about the use of the economic valuation methods to measure environmental impacts. Although they are experienced professionals and are completely familiar with the changes caused by Brazil's decision to adhere to the International Accounting Standard Board's framework, the accountants adopt a conservative stance regarding the use of values obtained in hypothetical markets or estimated values.

This knowledge should be emphasised because the results of the research confirm that the accountants of the power sector who replied to the questionnaire agreed that the environmental impacts generated by the sector's activities should be accounted for. However, their conservative stance contradicts this perception, due to their avoidance of using values obtained through estimates.

The conclusion is that there is a vast field of research that has yet to be explored by accounting in the environmental accounting area, especially in terms of the measurement of environmental impacts caused by diverse economic activities. There will have to be a change in the paradigm among the accountants surveyed if what is new in the international accounting sphere is to be accepted and absorbed into generally accepted accounting practice in Brazil. Although one cannot generalise, it is likely that a similar result will be found in other sectors.

Another important aspect of this research that should be highlighted is the fact that even though the power sector is well structured and organised in terms of the knowledge, development and use of economic valuation methods for valuing the environmental impacts caused by the power sector, this knowledge has not yet reached the sector's accountants. This is revealed by the fact that in the case of questions relating environmental impact to valuation methods, a very high proportion of respondents did not choose any option (58% of respondents), even though there was always the possibility of choosing the "do not know what to opt for" alternative.

As a continuation of the research undertaken and the results obtained, it is suggested that accountants apply the valuation methods used to calculate the sector's impacts in a specific case study. After determining the values to be used by accountants in the accounting (internalisation) of these values, it is suggested that the impact of the use of these values on the equity of power sector companies be observed. It is also very important to use interviews so that qualitative data can occupy a more important place in the information obtained by future inferences.

Another suggestion is to apply this content to the thermo-electric power plant sector, with its potentially polluting activities. Moreover, this sector has already mapped environmental impacts and the methodologies proposed to value impacts were defined, similarly to the hydro-power sector, in the study by Tolmasquim *et al.* (2000).

It should also be verified whether the results of accountants' choices of valuation methods for measuring impacts caused by activities can be applied by environmental economics; that is, the suggestion is to research whether environmental accounting can impact environmental economics, by attempting to apply the choices made by accountants.

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8 References

COMASE/ELETRORÁS. **Referencial para orçamentação dos programas sócio-ambientais**. Rio de Janeiro: MME/ELETRORÁS/COMASE, 1994.

COOK, A. Emission rights: From costless activity to market operations. **Accounting, Organizations and Society**, v. 34, p. 456-468, 2009.

DIEREN, W. V. **Taking nature into account: a report to the Club of Rome**, 1a. ed., vol. 1. (W. v. Dieren, Ed.) New Yourk, USA: Copernicus. 1995.

DIXON, J. A.; Scura, L. F.; Carpenter, R. A; Sherman, P. B. **Economic Analysis of Environmental Impacts**. Londres: Earthscan Publications, 1994.

ELETRORÁS – DEA. **Avaliação de passivos ambientais: roteiros técnicos**. Centrais Elétricas Brasileiras S.A., DEA; coordenado por Fani Baratz. – Rio de Janeiro: Eletrobrás, 2000.

GRAY, R., BEBBINGTON, J., & Walters, J. **Accounting for the environment**, vol. 1. (C. A. Accountants, Ed.) Paul Chapman Publishing, 1993.

MOTTA, R. S da. **Manual para Valoração Econômica de Recursos Ambientais**. Brasília: Ministério do Meio Ambiente, dos Recursos Hídricos e da Amazônia Legal, 1998.

MOTTA, R. S da. **Economia Ambiental**. Rio de Janeiro: Editora FGV, 2006.

TOLMASQUIM, M. T (COORDENADOR). **Metodologias de Valoração de Danos Ambientais Causados pelo Setor Elétrico**. Rio de Janeiro: UFRJ; COPPE. Programa de Planejamento Energético: 2000.

TOLMASQUIM, M.T., Seroa da Motta, R., La Rovere, E. L., Barata, M. M. de L., Monteiro, A. G. **Environmental valuation for long-term strategic planning — the case of the Brazilian power sector**. *Ecological Economics* v. 37, p. 39–51, 2001.

ⁱ The COMASE is a committee that was created in 1988 as part of a group of measures designed to increase Eletrobrás' institutional actions in the environmental area and is composed of professionals representing 23 companies in the sector. In 2003, it was replaced by the Eletrobrás System's Environmental Committee (Comage), subordinated to the Eletrobrás System's Superior Council (Concise). With the restructuring of Concise in 2005, the Comage was succeeded by the Environmental Sub-Committee (SCMA), under the coordination of Eletrobrás' Environment Department and subordinated to the Operation, Planning, Engineering and Environment Committee (Copem), coordinated by Eletrobrás' Engineering Directorate.

ⁱⁱ The Brazilian Electric Power Sector Accountants Association - ABRACONEE, is an administratively and financially independent non-profit organization, founded on November 6, 1986, that congregates accounting professionals linked to the electric power sector. Its mission is to promote the development of skills and the integration of the Brazilian electricity system's accounting community. It has around 350 members.