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## A Political Economy Model of Regulation Explained Through Fuzzy Logics

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***EUROPEAN REGIONAL SCIENCE ASSOCIATION***

**44.th European Congress  
25 - 29 August 2004**

***A Political Economy Model of Regulation Explained Through Fuzzy  
Logics***

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## **A Political Economy Model of Regulation Explained Through Fuzzy Logics**

### **Abstract**

The basic problem of environmental regulation involves the government trying to induce a polluter to take socially desirable actions, which ostensibly are not in the best interest of the polluter. But the government may not always be able to precisely control the polluter. To further complicate matters the government faces a complex problem of determining exactly what level of pollution is best for society. In reality the government faces pressures from consumers and polluters.

There are some important lessons to gather from the analysis of current models of regulation. One is that there are many imperfect links between the legislature and the pollution-generating process. In this case regulation may be excessively costly, may result in considerable cheating, and may result in excessive pollution. Another lesson is that legislature does not necessarily act as an efficient benevolent maximizer of social well-being.

The authors intend in this paper to explain the current view of political models of regulation, analysing them for their complexity, and attempt to provide a reasonable explanation of their functioning recurring to fuzzy logics.

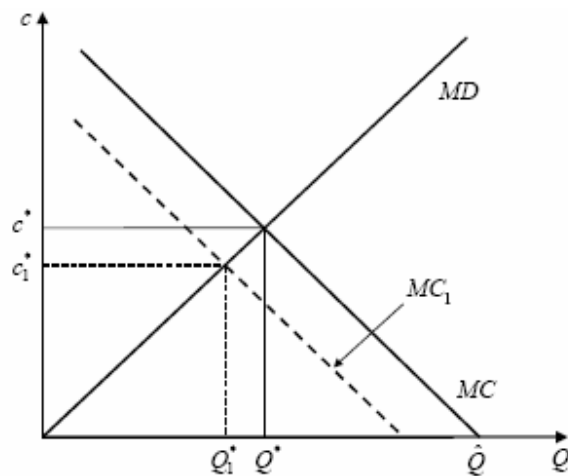
Understanding how the *browns* and *greens* interact with the legislature and regulatory agencies can to some extent explain the current environmental regulations. The fuzzy approach, intends to allow for easier understanding of these interactions, and provide an answer for more effective decision making.

**Keywords:** Environmental Regulation, Environmental Economics, Fuzzy Logics, Models, Pollution Control, Sustainability

### *Environmental Regulation in Context*

For several decades, the modernization of societies has occurred at the expense of environmental degradation. While most countries have had for some time relatively good legislation to deal with “green” issues (i.e. management and preservation of natural resources) lack of effective institutions, priorities, and proper implementation has made this legislation largely ineffective (Kolstad, 2000). The problem of “brown” issues, that is pollution, is relatively newer and, thus, even more poorly dealt with.

From an economic perspective, problems of environmental pollution arise because resources are not allocated in an optimal way. The market is said to fail because the costs of a polluting activity do not fully reflect its harmful impact on the environment. This problem can only be overcome by some sort of institutional solution, most frequently state intervention. In an ideal world, the task for policy makers is quite simple. Figure 1 shows the most basic textbook representation of this decision problem, where  $Q$  stands for the quantity of pollution emission per period,  $MD$  for marginal damages of a polluting activity,  $MC$  for marginal abatement costs and  $c$  for cost. Policy makers only have to choose a policy instrument that reduces pollution from the unrestricted level  $\hat{Q}$  to an optimal level  $Q^*$ , where  $MD$  equals  $MC$ .



*Source: Kolstad, C (2000)*

Figure 1 - The Efficient Level of Flow Pollution

Unfortunately, in the world of actual policy making uncertainty about virtually any decision parameter has non-trivial consequences for the desirable outcome. As can be seen in Figure 1, assuming just a different marginal cost curve  $MC_1$  immediately changes the desirable optimum from  $Q^*$  to  $Q_1^*$ . This underlines the potential impact of different information on pollution abatement costs and the crucial importance of having at least reasonably accurate information on the true costs of pollution abatement. Moreover, it highlights the ability of each actor or group of actors that holds credible information on the costs and benefits of

pollution abatement to influence the shape of the environmental policy measure. This raises a couple of questions. Given all these difficulties, how is an actual environmental regulation designed? How stringent can it be and how stringent is it? What does this imply for technology? To answer these questions, it is necessary to explicitly consider which actors or groups of actors may be involved in the design of an environmental regulation, what objectives they pursue and to what extent these objectives can be attained.

It is common knowledge that environmental degradation is often institutional in nature. Lack of political will, overlapping institutional mandates, limited capacity and budgets, inadequate environmental standards, procedures, and enforcement all contribute to a difficult management of environmental issues. This is so even if environmental awareness exists and officials understand the importance of sound environmental management. These concerns are echoed in European Union that identifies institutional fragility as a key barrier to successful environmental management. (Roediger-Schluga, 2000).

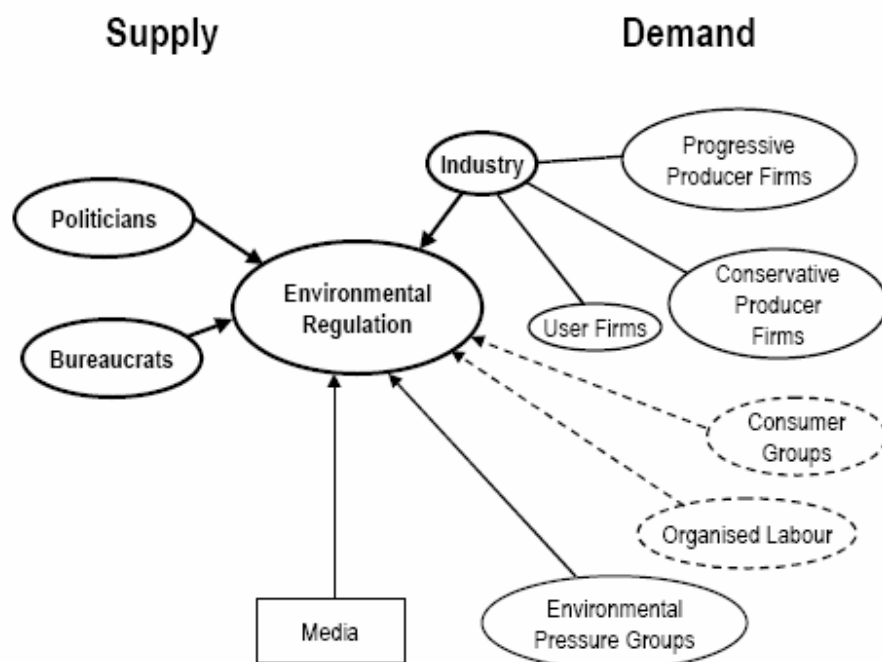
Environmental policy is characterized by overly ambitious and strict environmental standards that cannot be realistically enforced either because countries lack the capacity to do so or because of pressures from the private sector. Indeed, enforcement of such strict standards might involve sacrificing some economic growth.

However, even more troubling are the means by which the implementation of the strict environmental standards is pursued. While the law allows for the possibility of economic instruments, the primary means of implementation have been command-and-control instruments that have guaranteed environmental impact.

Since policy makers cannot fall back upon unambiguous and generally accepted estimates of benefits and costs of pollution abatement, the urgency and scope of an environmental problem as well as possible strategies to remedy the problem are subject to a social and political negotiation process.

Actually, society has different actors arguing in favour of different types of environmental intervention and having different pressure powers over political process of decision. The public authority and the non governmental organisations tend to favour interventions through command and control policy instruments, claiming for effectiveness in controlling pollution; on the other hand, environmental economists tend to enhance the economical rationality and the implementation of market-based instruments that induce a rational distribution of implementation costs and better achievement of efficiency goals Cabugueira(2004).

In order to understand the process of environmental regulation, the potential stakeholders in the political market of environmental regulation are depicted schematically in Figure 2.



*Source:* Roediger-Schluga, 2000

Figure 2 - The political market of environmental regulation

The core participants in this framework are politicians and bureaucrats on the supply side and representatives from industry (and firms) on the demand side. Environmentalists also demand certain kinds of environmental regulation, not being part of the core stakeholders since they only act as pressure groups. Demands on environmental regulation may also be expressed by consumer and worker groups, which are represented with a dotted line due to their little influence on the making of the regulation.

Environmental regulation is supplied by politicians and bureaucrats. Politicians are crucial actors in the political market, as only they have the power to adopt binding rules for all other actors. It is important to emphasise that these actors need political support, either through votes or financial support. Since voters care about their health and the state of the environment, politicians will take these issues into account. However, voters also care about income and jobs. For this reason, politicians will supply environmental regulation subject to the constraint that it is not politically harmful through adverse effects on income distribution, employment and international competitiveness (Verbruggen, 1994).

The bureaucrats exist because politicians need specialised knowledge and resources to design an environmental regulation. (Niskanen, 1994).

From figure 2 it can be understood that the different interested parties on the demand side have different roles and importance, this is because the number of firms is smaller than the number of environmentalists, and still smaller than the number of consumers or workers, benefits from lobbying are more narrowly distributed among firms, which increases the

incentive to spend resources on obtaining such benefits. Moreover, individual contributions are more significant. Also, business firms tend to have more resources, which may render even substantial contributions negligible in their view. Hence, industry associations may be overrepresented in the political arena relative to other interest groups (Keohane *et al.*, 1998).

There is obviously much detail missing in figure 2: although in this framework environmental regulation is restricted to the schemes provided by the public regulation process, voluntary participation of industry in the regulation process is edging forward and gives way to more flexible regulation structures (Cabugueira, 2004; Lévêque, 1996); besides, lobbying is not taken into account. Nevertheless the essence of the process is depicted there. The main lesson to be taken is that there are many imperfect links between the legislature and the pollution-generating process (which on the figure is also not taken into account). Since the legislature cannot physically control pollution directly, it must rely on indirect means to obtain its ends, and often these indirect means may be less than perfect (Kolstad, 2000).

Another lesson to be taken is that the legislature does not necessarily act as an efficient benevolent maximizer of social well-being, this is so because of the different interest groups involved in the process and their ability to enforce their position.

### ***Water Regulation in Portugal – An Example***

According to Portuguese legislation not only abstraction of water and discharge of effluents but all uses of the water domain are subject to licensing even when on private property. This concept is instrumental in supporting an integrated approach to water management.

Water quality management although an essential component of water management, was left largely unregulated until 1990. Only when environmental problems emerged and had to be taken in account in the political agenda, the Ministry of Environment and Natural Resources was created as an independent Ministry. Until then it was simply a branch of the Ministry of Planning and Territorial Administration.

At local level, the municipalities have been responsible for the operation of water supply and waste water systems and costs have been established in political terms that do not reflect the full cost of the service.

The need to incorporate EU Directives in the Portuguese legal system helped to overtake this situation. Decree-Law (D-L) n° 74/90 - replaced later for D-L 236/98- established criteria and standards for the protection, conservation and improvement of water quality, taking into account several uses. This legal document brought into the Portuguese legislation most of the EU Directives related to water quality.

There has been a long tradition in the Portuguese administration of river basin agencies that by 1993 would be replaced by an organizational structure called Regional Directorates (DRARN) not corresponding to the river basins, and having relevant jurisdiction over

water management. Water management was performed by these Directorates together with other environmental activities, losing this way a specialization and emphasis on water. They also have had responsibilities for the implementation and enforcement of EU legislation within their area of jurisdiction. D-L 97/2003 carried out some institutional changes namely concerning the transformation of the Regional Directorates (DRAOT) although having quite the same competences. D-L n°191/93 created an Institute for Water (INAG) -National Authority for Water in the near future- responsible for policy making at national level, for the preparation of water plans and for the construction of major water structures. D-L 189/93 created the Directorate-General for the Environment, now Environmental Institut, the main agency responsible for defining strategic objectives and coordinating all areas of environmental management, with some specific duties in the water sector besides having the main responsibilities in preparing national legislation according to EU Directives. D-L n° 379/93 also published in 1993, created a new model based on an entrepreneurial approach to water services and a semi-privatisation of these services. These legal documents promote large scale water supply and waste water treatment systems, managed by companies with a majority of public ownership - public owned or semiprivate companies - called multi-municipal systems and made possible having private companies managing smaller systems under a contract of concession with municipalities. The multi-municipal systems could also operate under a contract of concession with central government.

In 1994 some other legislation on water planning and management was established to complement and counterbalance these reforms- Decree-Law n° 45/94 requiring the preparation of 15 River Basin Plans and a National Water Plan as well as the implementation of the corresponding 15 River Basin Councils and a National Water Council; D-L n° 46/94 establishing new licensing regime and reinforcement of DRARN and Institute for Water powers and D-L n° 47/94 implementing the user-pays-principle and polluter-pays principle for all licensed uses of water. These uses are subject to the payment of a tax directly proportional to the amount of water that is used, to the scarcity of water at the specific location and to the economic value of the water for each specific sector and inversely proportional to water availability. The goal was that these principles could be gradually introduced to become fully operational by 1999 for domestic and industrial uses and by 2004 for irrigation withdrawals. In fact the procedures for computing the amount of these taxes and the parameters to be included in its calculation were not entirely established yet besides the implementation of river basin plans and the future sustainability of the water systems that were being built on the basis of public investment and EU funds.

This legislation aimed to bring some legal stability to the water sector on all uses of the public water domain. In December 1994 the D-L n° 319/94 established the guidelines and the general framework for the contracts of concession of the public or semi-private multi-municipal systems. This is considered an important issue because it establishes a model that can be followed by municipalities in their contracts with private companies, although it does not apply directly to these contracts.

These legal documents constituted a step towards the regulation of water market, transferring some of the responsibilities attributed before to the public authorities, to the civil authority, thus increasing the level of private companies participation. This is intended



to contribute to improve the quality of the service and to increasing the investment capacity of the water sector. Indeed, the partial privatization of the water industry has brought the highly subsidized prices of water closed to more realistic values, although problems of equity can arise in a context of an essential good that is water.

The implementation of these principles would be very important for guarantee of a sustainable use of water systems that are being built on the basis of public investment, strongly reinforced by EU funds.

Environmental legislation is supplied by politicians and bureaucrats and in democracies, voters can express their care about their health, their income, their jobs and the state of the environment, which brings politicians concerned about these issues. These agents will supply environmental regulation subject to the constraint that it has not adverse effects on these subjects (Verbruggen, 1994).

This is the core issue why the complexity is not in the task of incorporating the EU Directives in national legislation, but in the effective enforcement of this legislation. The idea was that major uses could be paying appropriate taxes, but actually it has been a virtual goal.

Besides the voting process, there are some other reasons that can be pointed out as a cause for the difficulties quoted. It is very difficult to enforce the legislation concerning licensing and paying taxes because there is a well established tradition of free water appropriation and because enforcement requires an efficient administration, which is very far from the current situation. The registration of all users is indeed an enormous task.

Portugal still has lack of satisfactory infrastructures and connection of houses to these systems, although the impressive evolution in these field in recent years. Old industrial units are related with the most serious problems of industrial pollution because many of them don't have clean technologies (Serenó, 2002). Control and monitoring of water quality in rivers and coastal waters is also a problem, as there are some institutional deadlocks. This is because of the severe cuts in budget and human resources due to the Stability Agreement in EU. Agriculture related pollution is also a problem with difficult resolution, as farmers attitudes and practices are far from environmental friendly. Investment effort and other non-structural measures as adequate principles to ensure a long term sustainability of the system are needed for the development of backstage technical capabilities and adequate planning procedures.

At the local level, municipalities although sharing responsibilities in defining water policies and applying national legislation, tend to concentrate on the problems of water supply and waste water disposal, as they are the responsible entities for these jobs. They have an important role in public health as supervisors of the quality of drinking water.

The residential distribution of water and the small systems serving one or a small number of municipalities remain the responsibility of municipalities which may subcontract private companies as said before.

All Portuguese legislation up to this time concerning water sector regulation had a relevant impact on the institutional framework for water planning and management. For the first time river basin planning becomes a legal obligation, the water services could be operated in a more professional manner and the use of water services could correspond to a financial compensation. The problem is that only theoretically one does can consider so.

Over the last years, the traditional sectoral approach to environmental protection was abandoned, primarily influenced by the concept of sustainable development. The key strategy is to integrate the environment into other policy areas, as a driving force for a rationale and a sustainable use of natural resources and to avoid depletion, and price has a determinant role in environmental policies. A comprehensive integration is the goal of EU policies itself as they promote the adoption of integrated strategies.

The main objective of EU concerning water policies is well established in COM, (2000) where it is clear that the development of water pricing policies enhancing the sustainability of water resources is crucial. The idea is that the full recovery of financial costs and the integration of environmental concerns are the favorite way to use efficiently water.

European Water Framework Directive (Directive 2000/60/CE) includes for the first time and in a explicit way, economic concepts in water management and although being very flexible about specific methodologies of implementation in each member state, it gives a special importance to the economic analysis of the water sector. So although each member state can adapt the principles concerning this matter to their own law, they have to try to comply with the idea of Polluters Pay Principle and full cost recovery of water services. The guiding document for the implementation of the Water Directive in what concerns water economics (WATECO, 2002) reinforces the importance of these economic aspects in order to achieve the environmental goals and further studies(Palma,2002, Gonçalves and West) have been carried out to analyse the implementation of economic analysis of the Portuguese water sector.

At the moment the Portuguese government is about to approve the Water Law, which intends to be the transposition of the Water Directive and which has given rise to much controversy as it seems to reinforce clearly the lobby of the water industry besides other limitations whether of conceptual or methodological nature(Sereno, 2002; Aguapública, 2004;Tovar 2004;CNA 2004).

This Water Law set up two principles: The compulsory nature of the economic analysis of water uses in each hydrographic region and the cost recovery principle in what concerns water services, including environmental and economic costs.This principle is to be considered in Portuguese water pricing policy until 2010.

Pricing water is the way to recovery costs and to incentive rationality in water usages and water markets are seen as the better way to achieve environmental goals. INAG, the futur NationalWater Authority and DRAOT will have strong competences in what concerns water conservation in quantity and quality, and a new institution is created, named Hidrographic Region Administration - ARH with responsibilities (among others) in setting

the charges. Three kind of charges are set up in the Water Law: Environmental charges are due to the activities that have a negative impact on the water quality (negative externalities); user charges are due for the private usage of the water public domain; the regulation charge is applicable to the infrastructures beneficiaries. Futur regulamentation of the Law will establish the framework of these charges.

### ***Fuzzy Concepts Applied to Environmental Regulation***

Fuzzy logic is an intuitively compelling technology that actually enhances computer intelligence by making the computer act more human. Whereas most computers are limited to strict binary programming (yes/no and true/false) much like standardized tests, fuzzy logic seeks to round the edges of hard logic data. The appeal of fuzzy logic for different subjects is that there are very few times in real life when problems have completely black-or-white solutions, and numerical data are not possible to ascertain. Commonly it can be said that fuzzy logic deals in shades of grey.

In 1951 a professor of electrical engineering at Columbia University, wrote a paper called “System theory”, which founded a new discipline of measuring hard data. However, Zadeh, in his studies of complex systems, found that human interactions in organizations defy predictable behaviours and, therefore, hard data are not always possible or accurate in tracking processes. By 1962, Zadeh (quoted in Abbott, 1996) concluded that individuals reason in fuzzy terms.

Fuzzy logic has great applicability to a very wide range of subjects, and from reviewing literature it can be seen this term applied to subjects as learning organizations, leadership, neural networks, etc. This is because there is the urgent need to search creative methods of measurement. Most of the issues raised in these topics are led by human beings, not numbers! While hard logic data are important in giving feedback on the success of processes, it is the human resource that gives meaning to the numbers. The authors are interested in fuzzy logic because they can see the benefit of applying its principles in order to explain and helping with the environmental regulation process.

In many instances where hard logic ends is where fuzzy logic begins. Measuring and understanding the relationships between the different interested parties the regulation process is elusive, inexact and fuzzy.

### ***The Fuzzy Approach to the Water Regulation Model***

Let’s go back to figure 2, and consider the following question what type of regulation will the different interest groups demand?

Environmentalists will demand stringent, highly visible regulation to help them to raise their public profile. Should consumer groups and worker organisations be involved? In that

case they will demand that the environmental regulation does not raise the prices of the goods they consume or hurt their members jobs and income, respectively.

Firms will demand regulation that does not harm their competitiveness. Thus, they will attempt to minimise compliance costs and avoid costly interruptions of standard operating procedures that stringent environmental regulation might entail. Moreover, at least some firms may attempt to benefit from environmental regulation either by creating markets for their products or by obtaining monopoly rents through a restriction of competition (Stigler, 1972).

Accordingly, producers of 'green' products, technologies or services may try to utilise the regulatory framework to promote their output and win market shares from their 'dirty' rivals. Also, domestic firms may attempt to employ environmental regulation as a non-tariff trade barrier against their foreign rivals. In the same vein, technologically advanced firms may attempt to use stringent regulation to drive their less advanced rivals out of the market. In all these cases, some firms may actually favour stringent regulation, signalling to policy makers that the costs of compliance are low.

All of these issues raised are fuzzy in nature. This is an explanation of why is so difficult to enforce regulations imposed by governments.

Figure 3 shows us the current water regulation model in Portugal.

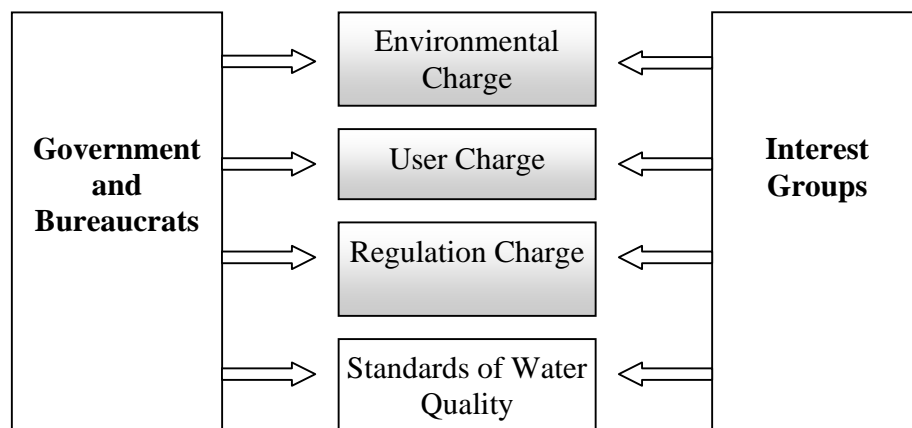


Figure 3 – The Water Regulation Model in Portugal

The shaded areas in the model represent economic instruments. The standards of water quality are normative regulations, usually a transposition of European Directives.

In figure 3 it is also represented the government and bureaucrats and the different interest groups (please refer to figure 2).

In order to apply the fuzzy concepts we need to understand that any negotiation process between government and interest groups is characterised by an information set, which will allow establishing criteria upon which can be taken rational decisions.

Due to the existent conflicts amongst the interest groups, the authors think that the use of fuzzy logics is a valuable option. Figure 4 illustrates the conflicts of interest.

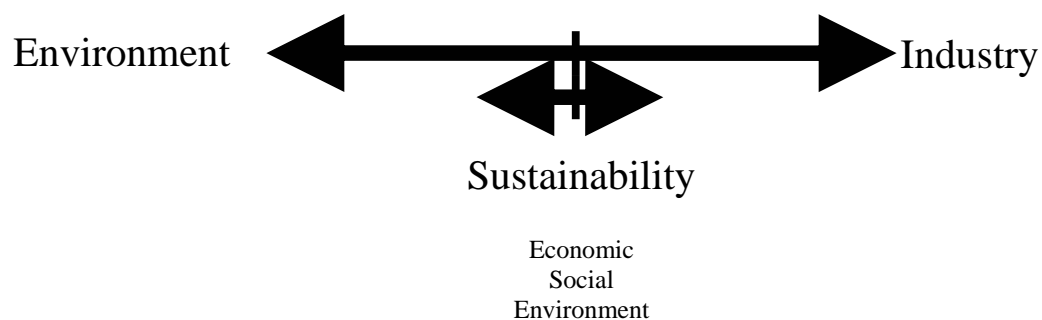


Figure 4 – Conflicts of Interest Arrow

On the environmental side, the interest groups will require strong legislation in order to protect the environment, without taken any consideration for the economics. On the other hand, industry will require that legislation will not be a burden to their productive process, and hence, doesn't jeopardize their profit share.

These are two opponent views, and government will bounce back from one to the other, according to the current political agenda.

In order to became more sustainable what is needed is a compromise between the different extremes towards an equilibrium – we need to shorten the arrow (see figure 4).

How can we then apply the fuzzy concepts in order to achieve this compromise? First of all it is needed to define a set of feasible and relevant alternatives. Let's take the example of user charge (from the Portuguese water regulation model).

Relevant alternatives:

1. Implemented by the government (A1)
2. Private implementation with government regulation (A2)
3. Private management only (A3)

These alternatives are to be judged on the basis of various evaluation criteria. For this purpose we will use the sustainability pillars (economic, social and environmental).

Economic criteria:

1. Impact on water cost recovery (C1)
2. Impact on the industrial, services and agricultural sectors (C2)

Social criteria:

1. Residential attractiveness (C3)
2. Tourist attractiveness (C4)

Environmental criteria:

1. Water quality (C5)
2. Eco-system equilibrium (C6)

It appears that concerning the information of the diverse impacts on the regulation process of the user charge, the degree of uncertainty is high, so that quantitative information on these impacts is not often available. Hence, the representation of such impacts in fuzzy terms seems very appropriate.

A multi-criteria fuzzy evaluation matrix is presented below.

Table 1 – Evaluation Matrix for a Fuzzy Water Model Problem

ALTERNATIVES	CRITERIA					
	C1	C2	C3	C4	C5	C6
A1	Bad	Excellent	Moderate	Moderate	Bad	Bad
A2	Moderate	Moderate	Good	Good	Good	Moderate
A3	Excellent	Bad	Moderate	Moderate	Excellent	Excellent

The rationale beneath this matrix is that the price goes up without State intervention, and this will have a bad, moderate, good or excellent impact on the different criteria under analysis.

In addition to this fuzzy evaluation matrix, an assessment of the priority structures of the diverse interest groups is required. For the purpose of this analysis, the following interest groups are considered:

1. Industry (I1)
2. Water Industry (I2)
3. Consumer Groups (I3)
4. Environmental Pressure Groups (I4)

In Table 2, is presented the linguistic evaluations of the alternative plans according to each interest group presented.

These evaluations were assessed based upon theoretical knowledge. To further study this matter, it is necessary to undertake more precise evaluations based upon surveys and interviews, in order to fully understand the different issues amongst the interest groups.

Table 2 – Fuzzy Evaluations of Alternatives According to each Interest Group

ALTERNATIVES	INTEREST GROUPS			
	I1	I2	I3	I4
A1	Good	Bad	Good	Excellent
A2	Excellent	Good	Excellent	Good
A3	Bad	Excellent	Bad	Bad

By applying fuzzy multi-criteria procedure for each pair of actions (A1, A2; A1, A3; A2, A3) it is possible to obtain different degrees of truth (for example comparing in terms of better, indifferent or worse).

From the analysis of the tables above, it can be pointed out some interesting conclusions:

- Privatising the water market without State intervention (A3) would mean that the price would reflect all costs involved;
- This would be “excellent” for C1, C5 and C6, respectively, cost recovery, water quality, and eco-system equilibrium. This is because if the price goes up, then quality increases as the demand of water will be rationalised;
- It is also interesting to see that from the analysis of table 2, it can be seen that in spite of water quality increase with privatisation (A3), the environmental pressure groups (I4) prefer public provision.
- For the water industry is clearly advantageous to completely privatise the water sector, as this would create a producer surplus, since they usually work under a context of natural monopoly;
- For other interest groups under analysis, their interest seem to run in parallel, as their interest is mainly related to cost and few considerations on the environment.

It is important to note that in case of “direct conflict of goals” game-theory elements such as the notion of “power” need to be considered. Furthermore, attributing to the same interest group the same weight can be an over simplification of this analysis.

### ***Conclusions and Further Research***

The authors intended with this paper to present an empirical model of water regulation using theoretical principles of fuzzy logics. By no means, did this work intended to be an extensive description of a real world application model.

This method is intended to provide help for decision-makers to find out which alternatives are most attractive given their preference structure, although, this will depend amongst others of their relative power and decision rules and practice. In the Portuguese example, it is known of the difficulty of implementing and enforcing environmental procedures.

The authors are researching this method as an effective tool for evaluation problems with conflicting objectives such as the environmental regulation process.

For further research the introduction of strategic elements in the analysis of coalitions will be undertaken.

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