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The Fuzzy Logic and the Fuzzy Approach: A Comparative Law Perspective

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Abstract

This paper intends to contribute to the epistemological discussion on classifications in comparative law through the explanation of the value of fuzzy logic and of the usefulness of the fuzzy approach in legal studies. The analysis will proceed as follows. After a brief introduction, section II outlines the state of the art of classifications in comparative law. In section III, the ways of thinking which can be applied in the activity of classification are illustrated. Sections IV and V are devoted to the explanation of the fuzzy set theory with the aim to understand the relevance of fuzzy logic in legal research and to illustrate a few applications of the fuzzy approach. The final section is dedicated to some reflections on the extent to which it is reasonable to adopt the fuzzy set theory in legal studies.

Keywords

Fuzzy Logic, Fuzzy Approach, Classifications, Comparative Law

Sintesi

Il presente lavoro intende contribuire alla discussione epistemologica sulle classificazioni nel diritto comparato mediante l'illustrazione del valore della logica fuzzy *e dell'utilità dell'approccio* fuzzy *negli studi giuridici. L'analisi procede in questo modo. Dopo una breve introduzione, il paragrafo II delinea lo stato dell'arte delle classificazioni nel diritto comparato. Nel paragrafo III sono chiariti i modi di pensare che possono applicarsi all'attività catalogatoria. I paragrafi IV e V sono dedicati alla spiegazione della* fuzzy set theory *con l'intento di comprendere la rilevanza della logica* fuzzy *nelle indagini giuridiche e di illustrare alcune applicazioni dell'approccio* fuzzy*. Nell'ultimo paragrafo si riflette su fino a che punto sia ragionevole adottare la* fuzzy set theory *negli studi giuridici.*

Parole chiave

Logica *fuzzy*, approccio *fuzzy*, classificazioni, diritto comparato

This essay is an updated version of the paper published in Italian under the title: 'Riflessioni sull'uso consapevole della logica fuzzy nelle classificazioni fra epistemologia del diritto comparato e interdisciplinarietà', *Revista General de Derecho Público Comparado*, vol. 10, 2012, pp. 1-20.

I. Introduction

The fuzzy logic and the fuzzy approach here explained arise from two considerations. Firstly, legal comparatists have not provided much information regarding classifications. Secondly, progress made by scholars of other disciplines may be useful for anyone concerned with this topic. Some theoretical reflections are very interesting but are nothing more than the common way of thinking of human beings: only, their shortcoming is that certain things just do not leap out at us until they are named and justified at an epistemological level.

Legal comparatists should wonder more about the theoretical assumptions of their studies, that is epistemology, the scientific knowledge of comparative law as opposed to common sense. Wondering what comparative law means, and what kind of knowledge is necessary to perform comparative studies, implies looking outside the legal context. Philosophical discussions on the effectiveness of rules are not enough to ground the epistemological bases of those who compare legal systems. The study of law, as a cultural phenomenon, includes the structures of thought and also the way in which facts are perceived by the observer. There are many intelligibility models, and one needs to pay attention to them in order to establish an epistemology of comparative law (Samuel 2004: 35 ff., 57 ff.; Van Hoecke 2004: 165 ff.). In this perspective, interdisciplinary research could be of great importance.

Regarding the issue of scientific results from other areas of knowledge, we observe that interdisciplinary orientation has become a sort of leitmotif in academic circles but, despite the fact that legal comparatists make good use of other disciplines' references in their essays (Pegoraro 2012: 295 ff.), miscellanies and headings in encyclopaedias still highlight a sort of separation. On the one hand, social sciences representatives dialogue together on the features of comparative method; on the other hand, several contributions on this topic carried out by legal scholars remain confined to their subject area. For example, in the volume edited by Baldissera there are papers written by sociologists, political scientists, anthropologists, and historicians, but not by comparative legal scholars (Baldissera 2003). In the *Enciclopedia delle scienze sociali*, there are two contributions on comparison. The first one, by Smelser (1992: 107 ff.), explains the classical models of comparative analysis in social sciences. The second one, by David (1992: 116 ff.), reports the results achieved in the sphere of comparative law.

It must be said that, while for sociologists and political scientists – who also shape models, classify and compare – comparison is only one of the possible methods to apply in the analyses, which moreover symbolizes the «ugly duckling» in their studies (Delli Zotti 1996: 166 ff.), on the contrary, the comparative method in the legal sphere has been elevated to science, and legal scholars use alternative names to refer to the approaches used to make comparison between legal systems (Ancel 1974: 91 ff.).

If one thinks about the use that comparatists already make regarding the data from other sciences, these references can be conceived in a continuum. At one extreme of the continuum, there are mere extra-legal data, where a wider knowledge of a legal system – from the historical, political, social points of view that inevitably are reflected in the normative field – help us to better understand the context in which research is placed. This recurring activity, while valuable, does not amount to a synthesis between legal and extra-legal data; rather, it gives importance to the law-in-action. In the middle of the continuum, we can mention the methods and theories of other disciplines; the use in a prescriptive way of the predictive models forged by other sciences scholars; the use of results obtained in distinct fields to test their utility in the sphere of comparative law. Even in these cases there is not a synthesis of different manners of conducting comparative research, although the comparatists' level of understanding in relation to other disciplines is more intense. At the opposite extreme of the continuum there are studies where fundamental methodologies or paradigms of other sciences are applied, thus creating a new way of doing research (for other scales see Van Klink and Taekema 2008: 17 ff.; Siems 2009: 1 ff.).

The procedure that the observer should follow to make a synthesis between the legal field and other fields implies a "packaging activity" at the linguistic, conceptual, and functional level. This preliminary stage allows us to understand scientific methods and epistemological bases of different disciplines. Paraphrasing Markesinis (2003: 47), without a packaging of those rules in a comprehensible language for the legal scholars, and without a correct decoding of concepts to highlight their functionalities and their achievable applications in comparative legal research, the interdisciplinary dialogue can become a dialogue of the deaf. Or, it could fall into the cases described above of references to theories without using them, because it is impossible or because one does not know how best to employ their potentialities (see also Schrama 2011: 152).

Bridging the terminological gap on similar concepts is a first draft of the work to be done in order to facilitate a process of scientific integration. The premise for a mutual methodological acknowledgement resides primarily in the elaboration of a common linguistic code. Lexical shared platforms, from which to develop multidisciplinary research, enable a better understanding of an object of study in a more penetrating way. This type of activity is called «epistemological silos», where each scholar faces the problem with their methodological approach (Miller *et al.* 2008: 3). Secondly, the multiplicity of perspectives can lead to the improvement of interdisciplinary methods of analysis, to internalize paradigms of other sciences, and to formulate new questions. In these cases, we refer to «interdisciplinary collaboration» (Eigenbrode *et al.* 2007: 56).

Having briefly explained the context in which this essay lies, I will now try to contribute to the epistemological discussion through the explanation of the value of fuzzy logic and of the usefulness of what I have named the fuzzy approach in comparative legal studies. The article will proceed as follows. In section

II, I will outline the state of the art of classifications in comparative law. In section III, I will explain the ways of thinking which can be applied in the activity of classifying. In sections IV and V, I will present the fuzzy set theory with the aim to understand the relevance of fuzzy logic in legal research and to illustrate a few applications of the fuzzy approach. Finally, I will make some reflections on the extent to which it is reasonable to adopt the fuzzy set theory in legal studies.

II. Classifications in comparative law

«Categorization is the very process of reasoning itself» (Winter 2001: 70). The utility of classifications lies in their analytical strength. They enhance the understanding of complex phenomena by simplifying real world information by means of conceptual schemes; schemes that give rise to general and abstract models.

Truly important classifications are those which allow the most interesting and general propositions of some hypotheses, offering the maximum level of information with the least possible cognitive effort. This principle of cognitive economy is linked to the principle of the perceived world structure. The perceived world is not an unstructured set of equiprobable co-occurring attributes. Objects are perceived to possess an high correlational structure, according to the schemes already known in a certain culture and historical period. These two axioms affect both the level of abstraction of taxonomies created in a given society, and their internal structure (Rosch 2004: 92 ff.).

It is thanks to macro-comparative studies, where classifications are the focus of the analysis, that the science of comparative law as an autonomous discipline was founded, giving it a new object, a new aim and a new field of research (Constantinesco 2003: 56). In the case of micro-comparisons, the examined elements should respect the requisite of homogeneity (Pegoraro and Rinella 2013: 53). To be sure that two or more objects belong to the same class and therefore are homogeneous, classifications are necessary. Classification postulates the identification of certain criteria that elements are endowed with. In this manner, they could be inserted in a category or in another on the basis of those criteria.

Despite the path for which classification precedes comparison (on the respect of this sequence, where comparison can be made only after the classification, see Smelser 1982: 226 f.), it is obvious for an observer to move from a prior understanding of the object under analysis and to perform the comparative research (Constantinesco 2000: 103 ff.), improving their assumptions during the elaboration of hypotheses and of the classificatory scheme (Rescigno 1989: 9). At the cognitive level, these stages are conceived as sequences. They can be divided into three interlinked phases, that follow and alternate with one another, often recursively. The first phase is based on a multiplicity of perceptions and reasoning: abstract representations, search of analogies, classifications, generalizations, and

inferences. In the second phase, the hypotheses to be verified or disproved are formulated. In the third phase, the models are built (Tiscornia 1995: 3).

Returning to my topic, the nexus between the classification activity and the comparative stage is indissoluble, and it is also bidirectional, generating a process of mutual dependence where the results from new comparisons highlight some discrepancies compared to old classificatory schemes.

In the micro-comparison studies is quite obvious to omit the phase of classification, using the well-established categories. Legal comparatists often relegate to the margins the issue of classification, devoting their full attention to comparison. With the exception of those who have outlined the aims of the classifications, and of those who have considered the reasons that may lead to their success, there are not many works on the intellectual operations behind the classifications (Rescigno describes four aims of the classifications: description, evaluation, individuation of historical recurrences, obtain prescriptions; and he makes only a brief reference to some differences in the classifications. See Rescigno 1989: p. 9; with particular reference to the success of the forms of government, see Pegoraro 1997: 11 ff.).

Classifying means to group together, on the basis of similarities and differences, legal families and systems apparently similar. This definition is considered sufficient to close the issue (Pegoraro and Rinella 2013: 72). At the utmost, what can also be added to this explanation is that the classification activity is divisible in two stages. In the first stage, the method to follow must be chosen. Here it is necessary to identify the elements to be catalogued and the criteria that allow the creation of classifications. In the second stage, there is the phase of classification (Pizzorusso 1995: 151 ff.; Constantinesco 2003: 67 ff.). Scholars indicate that the optimum is achieved when a classification respects the requirements of exhaustivity (every object must be assigned to a class) and mutual exclusivity (an object can not be assigned to two classes), without demanding the rigor required in hard sciences (de Vergottini 2007: 54 f.; Tusseau 2009: 41 f.). What matters most is the degree of simplicity or complexity. If the classification is an over simplication, it is useless; if it is too detailed, it undermines the effort of classification (Pegoraro and Rinella 2013: 77).

The scientific contribution is particularly varied with regard to the models, i.e. the products of the classifications as syntheses of the complexity through logical categories. The model gives conceptual form to an hypothesis (Rinella 1997: 27 ff.; on the logic inside models, see Bognetti 1994: 170 f.). In this respect, Samuel identifies three reasons for the models' validation, related to the characteristics of correspondence, coherence and consensus. A model can gain credibility by virtue of the correspondence with the observer's perception of reality; or because it has an internal coherence, putting the accent on the qualities of the elements and their relationships; or because it is particularly appreciated by the legal community (Samuel 2004: 43 ff.).

Explanations and predictive hypotheses are offered by these abstract schemes or models. Categories have a heuristic value because they guide the analyses, and sometimes, during in the formulation of classification proposals, legal comparatists make use of the schemes created by scholars of other disciplines. Although it is easy to find the prescriptive element in the classification-description (on the connection between description and prescriptivity in the theory of the forms of State, see Rescigno 1989: 9. In relation to the forms of government, see Rinella 1997: 36 ff.), the prescriptivity, rather than part of the model, is an element inherent in the observer's perspective. It is a guiding principle for legal researchers, who are oriented towards studying rules, including cultural formants able to transmit binding norms (Sacco 1992: 46 ff.; Pegoraro 2008: 35 ff.).

The legal scholars' approach to knowledge is not so different from that of social scientists, even if the formers' method of research, the legal method, leads to distance themselves from the others. Legal comparatists make extensive use of historical and social data to better contextualize the *milieu* in which rules are effective. And there are no obstacles to sharing the same models, from which to deduce predictive explanations. The main difference being that for comparatists the predictivity assumes the peculiar character of the observations of legal formants. They have a prescriptive value, from the formal point of view and not necessarily from the substantial one. And as they share data and models, they can also share epistemological bases and methodological approaches.

III. Monothetic, polythetic, and radial categories

In the field of social sciences, scholars who have dealt with the issue of classifications more rigorously than legal comparatists, i.e. political scientists and sociologists, explain the intellectual operations that give rise to classifications.

The first operation derives from a conceptual specification. It is based on the premise that an object can move along a scale of generality articulated in an increasingly restricted way, fulfilling the criteria of exhaustivity and exclusivity. A typical example is the passage from genus to species. In these cases of intensional classification, the intension is given by the set of attributes that defines what needs to be part of a class. Another type of procedure gives rise to the extensional classifications. In this case, the objects of a set are grouped in two or more subsets according to the perceived similarities of their features or properties. The aim is to maximize their similarities, while emphasizing diversities compared to other classes. The last procedure – simply called classification – consists in the objects' assignment to the classes previously defined. One or more residual categories can be provided to achieve exhaustivity (Marradi 1990: 130 ff.; *id*. 2000: 185 f.).

Two ways of thinking express the logics that govern classifications, related to the monothetic and the polythetic categories.

The monothetic category is a legacy of Aristotle, since his principle of non-contradiction has influenced the Western thought and has left the binary or bivalent logic according to which every sentence can be only true or false (however, in the *Nicomachean Ethics* (1094 b, 11-28), Aristotle emphasizes that there are a few knowledges that are "mostly" good and are never certain and absolute). The monothetic structure is based on the idea that a certain number of features should be likewise shared by all objects for their inclusion in a class. Each feature is necessary and sufficient to establish the membership to a class (Mahmood and Armstrong 1992: 4; Piasere 1995: 6 ff. For a legal point of view, see Glenn 2010: 368 ff., who suggests that was Plato the first philosopher to introduce the bivalent concept; Winter 2001: p. 62). The positive aspect of the intensional classifications, which fall within the monothetic categories, is the simplicity and clarity of the sets, where one can assign new items easily and unambiguously (Brennan 1987: 215).

An example of Aristotelian thought applied to the study of the forms of government is reflected very clearly in a essay of Troper. His observations on the discrepancy between the ideal parliamentary and presidential form of governments and the effective systems in force persuade him to state that the traditional classification has all kind of weaknesses: it is an offence to logic; it does not teach us anything; it is based on the absurd assumption that the ideal models are real entities (Troper 1998: 246; see also Eisenmann 1966: 37). This assertion is fully understandable, as such the use of the monothetic categories is not the best way in which to study objects that shy away from rigid taxonomies, which occurs in legal research. The weakness in his reasoning lies in the fact that it is pointless to apply the Aristotelian logic in these cases and hence leading to consequences at a dogmatic level.

The classes are generated via an inductive process, based on perception and immediate recognition. They reflect the classificatory strategies that work in the mind, related to the so called polythetic categories. This concept indicates a principle, first introduced in the natural sciences and then used by cognitive psychologists and anthropologists, to overcome the dichotomous scheme. According to the definition offered by the biologists Sokal and Sneath, the polythetic classifications group «together organisms that have the greatest number of shared features, and no single feature is either essential to group membership or is sufficient to make an organism a member of the group». They allow us to compare in a weak form elements that resemble each other for some reason, but where no one shares specific features with all the other elements (the definition proposed by Sokal and Sneath is quoted by Needham 1975: 356. See also Pignato 1997: 172). The positive aspects of the extensional classifications, which fall into the polythetic categories, lie in the fact that the classes are closer to reality, contain an high content of data and they carry less risk of an arbitrary exclusion of significant features because the boundaries among the classes are not rigid (Needham 1975: 358; Brennan 1987: 216).

The elements that fall into a polythetic class share each other some "family airs". This idea recalls the concept of «family resemblance» used by Wittgenstein to mean that the way family members resemble each other is not through a specific trait but a variety of traits that are shared by some, but not all, members of a family. Games – board-games, card-games, ball-games, etc. – have become the paradigmatic example of a group that is related by family resemblances. If we observe them we will not see something that is common to all of them, but similarities, relationships, and a whole series of these instead (Wittgenstein 1967: §§ 65-67). A slightly different metaphor which conveys the polythetic thought is that of the «chain complex». The chain complex was elaborated by the psychologist Vygotsky – in the same year in which Wittgenstein elaborated his theory, 1934 – observing the way children play/think. They jump from one concept to another one on the basis of a common criterion that changes in progression: one object is connected with another by a common attribute, which in turn is connected to the next by a different attribute, and to another by yet a different criterion, and so on. According to this perspective, the objects are grouped together like the links of a chain, where the criterion changes at each subsequent passage, and there is no core or, better, «there is a single core that acts as the reference-sample, and it is without of any centre». In these cases one speaks of serial likeness (Vygotskij, quoted by Veggetti 1999: 545).

Needham offers an example of serial likeness, describing three hypothetical societies (A, B, C), each constituted by three features included among "p" and "v". A serial likeness is:

A: p q r
B: r s t
C: t u v

(Needham 1975: 351; on this issue, see also Fabietti 2003: 61).

In the same vein, the cognitive linguistic Lakoff stated that radial categories are the most common conceptual categories. They are not definable in terms of a list of properties shared by every item in a set. A radial category has a central object and certain conventionalized extensions. The latter ones are not rule-governed, and they can not be reduced to necessary and sufficient criteria, but neither are they arbitrary. Although the various extensions have little in common with one another besides their relation to the central object, each extension is related to their centre by means of an experientially grounded metaphor or metonymy (Winter 2001: 69 ff.).

The fuzzy set theory reflects the above-mentioned reasoning. The classical set theory assumes that one can clearly distinguish elements which belong to a set and those which do not, respecting the criteria of exhaustivity and mutual exclusivity. It applies the traditional Aristotelian thought, establishing a precise threshold for including or excluding an object from a category. Its paradigm is the notion of belonging on the basis of true or false condition.

Differently, the fuzzy set theory, proposed in 1965 by the mathematician Zadeh, imagines classes with vague boundaries. It admits that objects can belong to the classes only to a certain extent. In this way, Zadeh softens the dichotomous outcome which, while trying to chase precision, may lose its significance. The fuzzy logic infringes the bivalent logic. It conceives the uncertain position of the items expanding the paradigm of belonging through the notion of the «degree of membership» or «degree of belonging». The fuzzy set theory allows for more calibrated measures assigning to each object a score between 1 (full membership) and 0 (full non-membership). In the example of old persons, at the age of five a person is surely not old and her degree of membership will be 0, while she certainly can be defined old at ninety-five and her degree of membership will be 1. Between five and ninety-five years old there is a grey zone, numerically presented by degrees of membership greater than 0 and inferior to 1, which grow according to age (Sangalli 2000: 23; for graphical representations, see Brunelli 2001: 26).

This theory provides an axiom to the "truth of light and shade", which is not included in the black or white alternative, and which ultimately permeates the daily life, the reality of facts and that of phenomena observed in nature (Kosko 1999: 31). More specifically, the objects in the set are blurred, indeterminate, polysemic, and not the whole set. This theory conceives that an object can be part of a class in a partial way, neither fully inside nor fully outside. The element at the centre of the partition is the prototype for excellence, the object that symbolizes the emblem of the class (Brennan 1987: 216). Within a fuzzy set, boundaries can also be defined with clarity. Thus, the monothetic categories may appear inside the polythetic ones. These clear boundaries in fuzzy sets are called alpha-cuts (Piasere 1995: 6, 12 ff.). The fuzzy logic and the fuzzy set theory are widely accepted by mathematicians, and are applied by engineers, economists, sociologists, and anthropologists. These theories can also be useful for legal comparatists, as they are fully part of the epistemological and methodological bases of their discipline.

Every classificatory proposal is linked to the issue of pertinence, which is a subjective element. Pertinence has to do with the criteria chosen to divide and catalogue the objects. Tusseau considers pertinence to be the third feature of classification, together with exhaustivity and exclusivity which, as I have explained above, are not so essential in the polythetic categories. Meanwhile the latter two are objective characteristics, pertinence is a subjective element: the classes must have a useful purpose, developing functional concepts suitable to the aims of the

research projects (Tusseau 2009: 42). Pegoraro relates the issue of pertinence to the identification of the distinctive elements according to the theory developed by Constantinesco (1996: 223 ff.) which, as criteria for the catalogation, defines the various classificatory schemes. Also, he suggests approaching the classes to make progressive approximations, in order to overcome the problems arising from the discretionary choices made by the observer (Pegoraro 2010: 4).

Reducing the number of variables by trapping them in sharply defined sets is not a suitable approach to studying social phenomena. In my opinion, a suitable approach should be able to hold together in a logical and in a legal sense the largest number of items without losing the usefulness of the predictivity of the models. Recalling Wittgenstein, one must assess the extent of the concepts as when «spinning a thread we twist fibre on fibre. And the strength of the thread does not reside in the fact that some one fibre runs through its whole length, but in the overlapping of many fibres» (Wittgenstein 1967: § 67). For mathematicians, the purpose of fuzzy logic is to emphasize the significance, even at the expense of some loss of accuracy. The same function can be attributed to pertinence in legal research. Depending on the case, pertinence implies the identification of one or more essential elements, deemed significant to obtain an interesting result. In addition, for legal comparatists the use of fuzzy thinking does not necessarily lead to inaccuracy. Accepting reality for what it is means putting the maximum emphasis on models, acknowledging that legal data are social data and can not be inserted in monothetic sets.

At the comparative stage, it seems valuable to think in terms of fuzzy similarities. They are not to be conceived as operational limits but as a complex net of affinities within a specific conceptual framework. To some extent, these fuzzy similarities connect all the items in a class. Each object is set apart from the others regarding the extent of its function and its normative effectiveness. The heuristic value of a fuzzy approach to the comparative analysis is a methodology that emphasizes the comparison among legal objects closer to one another, where usually their similarities also concern the problems faced by these objects in the same class (Mattei 1994: 796). This approach can lead to more accurate observations, where the degree of similarity should be an element for making more relevant comparisons, and thus produce more interesting results at scientific level. Similarly, this applies to the degree of difference, if the aim is to understand the distance, i.e. the differences between items within the same class.

In addition to cataloguing an object, one can calculate the degree of membership to the class, while maintaining the complexity of the real world that the classical bivalent logic tends to exclude. How can one apply this principle, which in other sciences is represented by numbers, within the legal framework? The estimate of the degree of membership must be made on the basis of the legal elements which are the parameters of the research. Through these ones is possible to quantify, to weigh, by means of the legal method, the effective functioning of the object and thus to understand the prescriptive force of the criteria. One has

to keep in mind two conditions. The existence of a model that serves as a symbol in each class, and the possibility to identify clear contours, the alpha-cuts, inside the set.

The yardstick to determine the degree of membership of an object in a class is represented by the item put in the center of the set. The prototype theory helps us to understand how objects are classified by the human mind. As long as the cognitive psychology was adherent to the bivalent logic, no object of a class could have had a special status, all of them sharing the same properties. On the contrary, during the Seventies, Rosch showed there are asymmetries among objects and some of them serve as exemplars as they are perceived the most representative of a certain class and function as cognitive reference points in memory. Starting from these objects, the other ones are placed in the same category on the basis of the greater or lesser resemblance, i.e. on their degree of membership, compared to the prototype. A prototype effect is a consequence of this kind of idealized knowledge structure, for which some items will fit the model better than others (Rosch 2004: 92 ff.; Lakoff 2004: 163 ff.; Winter 2001: 76 ff.).

Consequently, from the prototype, one can determine the distance of the object and understand, by identifying similarities and differences, if an element is well located or whether it should be better placed in another class. In this activity, the alpha-cuts are like the fibres that give strength to the thread. The more objects fall in the alpha-cuts or are closer to them, the more relevant the class is. The thinner the fibre (and therefore the objects are distant to the core because there are more differences), the more the degree of membership decreases and the closer one is to the boundary of the class. This is the work that legal comparatists generally do. For this reason, realizing the epistemological values of the fuzzy logic and the fuzzy approach is important.

V. The application of fuzzy logic to law

V.1. Introduction

From the epistemological point of view, Samuel highlights that a few problems in the relationships between science and reality are ascribable to analytical methods used for understanding and representing facts (Samuel 2004: 39). Fuzzy logic offers several suggestions for further studies. After all, the nuanced reasoning is part of the cultural background of legal philosophers, accustomed to making use of vague concepts where the Aristotelian logic is not always the best approach.

Moreover, the polythetic thought can provide a valuable support to new legal classifications. It may also offer the opportunity to evaluate models which are no longer – or have never been – close to reality. Applying fuzzy reasoning, they could find a theoretical anchorage to rehabilitate them as conceptual categories still valid at the heuristic level. For example, the boundaries in the neo-parliamentary

and the semi-presidential forms of government are not always clearly defined. The same happens within federal or regional States, and between both categories. In these hypotheses, legal scholars could apply the criterion of the degree of membership. Using the fuzzy approach, these instances could be perceived along a continuum, instead of including them in separated monothetic models.

V.2. Fuzziness: vague concepts and legal pluralism

The phenomenon of the semantic uncertainty of legal norms is very well known. In the Sixties, Hart proposed the open texture theory. Influenced by Wittgenstein, he noted that legal rules have a core of certainty, and open texture and a penumbra of uncertainty at the borderline. His work was an attempt to analyze this peripheral area and the creative judicial activity within it (Hart 1961: 119 ff.). Other philosophers have adopted a nuanced perspective. Instead of trying to determine if a rule is valid or not, they have suggested an approach where validity is an issue of degrees (van de Kerchove and Ost 1995: 93).

Legal scholars who are involved in argumentation and judicial decision-making try to assign a "measured meaning" to indeterminate terms, such as good faith. Moreover, fuzzy logic has become a tool that someone applies or proposes to apply in trials considering the uncertainty of the meaning of certain words (Peña 1993: 57 ff.; Gomes Canotilho 1998: 35 ff.; Mazzarese 1997: 483 ff.; Nguyen 2008: 1257 ff.), and Winter, relying on a cognitive approach to the study of law, takes into account fuzzy logic in the mental process of the categories' formation (Winter 2001: 62 f., 83 ff.).

Contextualizing the issue within Hindu and Eastern thought (where the fuzzy set theory initially found more correspondence than in Western societies), Glenn has used the term multivalence to indicate that all categories are vague and that any effort to separate them is arbitrary and artificial, with the reality being a matter of degree. He prefers the expression multivalent logic instead of fuzzy logic for the reason that the former is less apparently pejorative and perhaps even more accurate than the latter. Multivalent logic tells us we should always think in terms of a continuum of values as opposed to those which are binary opposites. The advantage of this approach is to provide valuable information on the complexity of the world. In the European legal systems, its most obvious example is the range of national solutions more or less compatible with the European Convention on Human Rights, taken as not dictating a single, uniform solution but rather allowing a range or continuum of solutions and a corresponding margin of appreciation of them (Glenn 2010: 369 ff.; *id*. 2006: 229). From the same perspective, Delmas-Marty and Mathieu-Izorche (2000: 753 ff.) had already noted that it is possible to reason in legal terms even starting from vague notions, which do not pertain to the binary logic.

Multivalence is well suited to the issues related to legal pluralism (legal pluralism implies the presence of more than one centre of production of rules in the

social sphere. See Griffiths 1986: 1 ff.). Menski adopts the expression fuzzy law as a synonym of this concept, stressing the need to re-evaluate the traditional legal categories in order to manage the complexity of multi-ethnic societies, particularly the dilemmas that cultures and religions can pose to the legislator (Menski 2010: 30 ff.). Delmas-Marty, analyzing the hyper-normativity that characterizes the legal systems, invokes the *droit flou* to order the relationships among the various centres that produce rules, norms that can juxtapose one another. According to this author, we need a methodological option different from the binary logic to explain, still rationally and with distinct degrees of intensity, the current legal relations and to direct the choices in a non-hierarchical perspective, without imposing a unique decision (Delmas-Marty 1986; on the fuzzy logic linked to legal pluralism, see also Glenn 2010: 169).

V.3. The fuzzy approach in comparative legal studies

Moving our focus to classification in comparative law, fuzzy logic surfaces in a scattering of essays.

Even if not explicitly mentioned, fuzzy logic seems to hold up the tripartite taxonomy of the legal systems proposed by Mattei, who introduces the «judgement of prevalence» (that resembles the degree of membership coined by Zadeh) to indicate that the legal systems may present at the same time and to different degrees more than one criterion among those referred to (Mattei 1994: 782. In a later english paper, he translated the judgement of prevalence as «impression of "hegemony"»: *id*. 1997: 21). The variable nuances of the legal systems towards one character rather than another introduce a dynamic conceptual framework instead of a rigid scheme. It is more realistic and permeable to any changes.

Other comparatists explicitly make reference to fuzzy logic in their studies. Regarding end-of-life legal issues, Casonato has stated that the legal systems generally inclined to prohibit every action that directly causes the patient's death are not so rigidly separated by the legal systems that allow individuals the unlimited right to decide on their life and death. In actual fact, they are not distinguishable in terms of sharp boundaries, but rather in terms of fuzzy sets (Casonato 2012: 523 ff.).

As for the application of the fuzzy approach, I have proposed the following method to justify a study on Roma minorities in the whole of Europe, since their lack of homogeneity could have affected the classificatory framework (Baldin 2012a; *id*. 2012b: 1 ff.). Being an analytical category, Roma include multiple ethnic features. They are characterized by a serial likeness and have in common some features like the links of a chain. A fuzzy comparative approach aims to analyze the alpha-cuts of the Roma category, that is those sharp edges that can be found in the communities who speak Romani language and those who have an itinerant lifestyle. Thus, the research should not be affected by negative data from those legal systems that, objectively, do not have to deal with one of these two instances

of accommodation. Consequently, regarding the linguistic claims, where Roma minorities are numerous, one would expect to find indicators on the use of the mother tongue at a higher degree than in those Countries where Roma groups are small, scattered and/or not interested in the recognition of the Romani language in the public sphere. Regarding Travellers, one would expect to find a legal status suitable to their lifestyle where they prevalently live. Using the fuzzy approach, this study attempts to establish connections among Countries with similar instances of minority accommodation to satisfy. The aim is to point out a trend that should emphasize similarities and differences without trying to delineate a general framework, which would not be valid in all Countries for each of the features used as parameters of this research.

Another example is offered by Pegoraro, in the last edition of his book on constitutional justice. This author criticizes the classical models of constitutional justice, that are no longer adequate in representing the current reality (Pegoraro 2015: 201 ff.). Consequently, he has suggested various new typologies adopting the fuzzy approach. His premises are based on two considerations. The fact that nowadays it is very difficult, or even impossible, to propose definitive solutions due to the global diffusion of constitutional justice with a corresponding elevated degree of hybridization among models. And the fact that the pertinence can be found in many elements, depending on the classificatory aim. Thus, there would be different classifications and also parallel classifications, including or excluding the same object. If we begin with concrete cases, and not with historical models, there won't be unequivocal results, but this is «the price to pay for the multiplication of legal solutions which [...] will be reorganized on the basis of the current situation» (Pegoraro 2010: 9). For these reasons, each Country can be inserted in more than one model, and his classifications are open to possible new proposals.

Briefly, a first example pertains to the political or jurisdictional character of constitutional courts, in which Aristotelian classes are not applicable. Practical experiences are rarely set as a dichotomy, with courts being only political in nature (as in Socialist States) or only jurisdictional (as in the United States, thanks to the doctrine of political questions). A fuzzy approach, proposing soft classifications, allows the insertion of the majority of the Countries in both types of control. A second example of classification considers the courts' structure, where one can identify many cases, viewed along a continuum. At one extreme, there are the (almost) unitary systems, where a unique court exercises all of the constitutional competences (i.e. Spain, Italy, Belgium, France, Romania). In the middle, there are the partially centralized plurality systems, where each territorial level has its constitutional court, in parallel with a federal constitutional jurisdiction (as in Germany and Austria) and, one step ahead, the partially decentralized plurality systems, in which ordinary judges and a supreme court exercise their competences without an overlapping of functions (as in Portugal, Greece, and non federal common law Countries). At the opposite extreme, we could teo-

retically find the completely decentralized plurality systems (as Russia, Mexico, Brasil, Argentina, and federal common law Countries). A third case of classification regards the types of functions, ideally divided into mono-functional systems and multi-functional systems. In the first class, some common law and Northern European Countries and a few Latin-American States can be inserted. The majority of the global experiences can be put into the second class, but with different degrees of belonging, related to the number of their functions. The protection of fundamental rights and/or the resolution of conflicts of competence, linked to individual direct access to constitutional courts, give rise to another typology. The extent of the parameter, the object of judicial review, the variety of subjects, the modality of access, the typology of decisions and their effects, are also chosen elements of Pegoraro's classifications. Fuzzy reasoning is the distinctive feature in all of these proposals.

VI. To what extent can the fuzzy set theory be applied in legal research?

This essay has tried to demonstrate the utility of an interdisciplinary perspective for solving particular issues. Just as comparative law plays a subversive role with respect to the other branches of law (Muir-Watt 2000: 505 f.), through the critical development of theories that offer a viable alternative to the traditional categories, demolishing dogmas, stereotypes, and ethnocentric views, so the interdisciplinary approach could play a similar role in the sphere of comparative law.

Here I do not question whether law could also be useful to some extent for social scientists, a matter for which Samuel gives a negative answer due to the epistemological backwardness of comparative law (2009: 431 ff.). It should be considered a success to be able to explain theories and methods of a particular science for legal scholars, to make their use in legal studies understandable, independently of the effective application of that theory or of the results achieved. It will be the task of legal scholars to use their imagination and to employ the suggestions deriving from various readings, trying to experiment their usefulness in legal studies.

The last question I pose is: to what extent can the fuzzy set theory be useful for legal scholars? Recently, the fuzzy-set qualitative comparative analysis (fsQCA) has been applied in a few essays devoted to codification and minority protection (Arvind and Stirton 2010: 1 ff.; Schwellnus, Mikalayeva and Balázs 2010: 117 ff.). These cases are interesting in order to solve this issue. The fsQCA is a method, developed by Charles Ragin and based on fuzzy set theory, sometimes employed in sociology and political science, that tries to combine qualitative and quantitative analysis. The fsQCA systematizes the representation of similarities and differences across cases and provides for the examination of complex patterns of causation.

In essence, this tool can be perceived as a fruitful approach when various criteria of comparison are adopted and various objects (e.g. Countries) are under examination. Conversely, when only one or two criteria are chosen, and when the research focus is oriented toward only two or a few objects, in my opinion the fsQCA is valueless. Indeed, its ultimate aim is to elaborate numerically qualitative results. It aspires to offer a sort of synopsis where the measure of each item expresses its different degree of membership in a particular set. If there is very little data to intersect, for example a unique criterion in different Countries – which is a frequent case in comparative legal studies –, this table will be a simple list of objects.

Even in the hypotheses of wide-ranging comparative research, with many conditions and many Countries, I argue that this method doesn't have a lot to offer legal scholars. This is because the analysis is carried out following the legal method; only at the end, will the results be converted into numbers using an appropriate software (the computer software can be downloaded at www.fsqca.com). It is worth noting that it is the author who decides which weight to allocate to each qualitative data. Clearly, precision and transparency of the codification rules, the so called calibration of fuzzy sets, are indispensable. In the process of set calibration, it is particularly crucial to specify qualitative anchors (Schneider and Wagemann 2010: 397 ff.). For example, Arvin and Stirton used the fsQCA method in order to identify necessary and sufficient conditions for the full or partial implementation of the French Civil Code in the German States of the early Nineteenth century. In a scale of seven levels of membership, they decided to bestow one of these weights for each data: 1.00 fully in; 0.83 mostly but not fully in; 0.67 more or less in; 0.50 neither in nor out; 0.33 more or less out (Arvind and Stirton 2010: 1 ff.). The final result explains in numbers what a legal scholar usually expresses in words, stating the item's more or less adherence to the model or to the centre of the set.

In conclusion, an interdisciplinary approach is a very useful tool for academics, provided that they pay attention to their scientific premises and aims in order to take good advantage of what other sciences can offer them.

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