Fuzzy Set Theory and Concepts: A Proposal for Concept Formation and Operationalization

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Abstract

The quantity-quality debate in social sciences also concerns concept formation and operationalization. The first approach has strong naturalist assumptions, while the second one focuses on the historical specificity of concepts. The solution to overcome this divide would be finding a path which balances the two perspectives. In this article we argue that fuzzy set theory can be a helpful tool for concept formation and operationalization. The application of fuzzy set theory to concept formation and operationalization provides, first, the opportunity of looking at concepts as complex constructs made up of attributes logically interconnected one with the other and, second, of measuring them accordingly. Thus, after presenting our general argument, we show a theoretical and an empirical application of how to use fuzzy sets in concept formation and operationalization.

Keywords: concept formation, fuzzy set theory, concept structure, operationalization, measurement

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1 Introduction

Concept formation strategies are based, like the social sciences, on the "quantitative" and "qualitative" divide (Goertz 2006). On the one hand, there is the naturalist approach which relies on classification and taxonomy as tools for concept formation (Sartori et al. 1975; Collier and Gerring 2008). On the other hand, there is the tradition drawing on hermeneutics, which mainly uses the ideal-type to define concepts. Both strategies have some shortcomings in the process of concept formation. The first has strong implicit naturalist assumptions, which can be inadequate to respond to the contingency of the empirical world. The second is particularly focused on the historical specificity of concepts, which may lead to their general inapplicability. Therefore, in concept formation we encounter the problem of complexity versus generality (Sartori 1970).[1] This issue also concerns operationalization, as concepts and measures are deeply connected (Adcock and Collier 2001). The solution to overcome this divide would be finding a path which balances the two perspectives and which takes a "configurative approach" (Goertz 2006). In this article we argue that an answer to this issue may come from fuzzy set theory.

What we propose is the application of fuzzy set theory to concept formation and operationalization. Since its conception, fuzzy set theory has been applied to several scientific fields (Zadeh 1965; Kosko 1993) and, more recently, to social sciences (Ragin 2000). However, fuzzy logic has not been applied yet to the problems of concept formation, despite several studies in psychology have shown that concepts never have sharp boundaries (see Belohlavek et al. 2009). The application of fuzzy set theory to concept formation and operationalization provides the opportunity of looking at concepts as complex constructs made up of attributes logically interconnected one with the other. This is because fuzzy sets allow the possibility of a "configurational thinking" (Lazarsfeld 1937; Becker 1998; Ragin 2000; Goertz 2006; Ragin 2008). Therefore, by using fuzzy set theory it is possible to combine attributes of a concept and make explicit how the parts are bound together. In fact, concepts can be built ideally – i.e. "strict" conceptual structures, based on necessity – but also using configurations of attributes which represent partially a concept – i.e. "liberal" conceptual structures, based on sufficiency (Goertz 2006:119).

We will show that fuzzy set theory allows seeing the process of concept formation as dynamic, underlining the diversity of the different configurations of attributes and producing concepts suited to the aims and interests of the researcher. Furthermore, we present a "mixed" strategy, which goes beyond the approaches based on sufficiency and necessity of the attributes, because it applies both. Using fuzzy set theory allows the researcher to define the structure of the concepts by applying its formal language. Eventually, using fuzzy sets can be a way to fill the gap between the quantitative and the qualitative approaches to concept formation and operationalization, because they use scales which are, at the same time, quantitative and qualitative (Ragin 2008:82).

This article is organized as follows. In the next section we briefly introduce the distinction between "quantity" and "quality" in the social sciences and its consequences on concept formation. In sections 3 and 4 we present how concepts and fuzzy set the-

[1] This is what Sartori expresses through the idea of intention and extension of a concept.

ory may be related. Then, we illustrate how to apply fuzzy logic to define concepts structures. Thus, we use two examples to show the necessity, sufficiency and "mixed" concept structures. We show that the way we structure and operationalize the concepts we use for analyzing social and political phenomenon is a very important step of the research process. In the first example, we will illustrate that fuzzy sets can be used to build different conceptual structures, based on necessity, sufficiency and a combination of them. In the second example, we will show how different measures depend on different conceptual structures and what the consequences might be in using these measures in empirical analysis. In fact, the way we build our concepts heavily influences the process of operationalization. In this example we illustrate the empirical differences between the AND, the OR and the "mixed" structure. We also show that the measures of concepts which have certain structures differ from measures produced by a standard technique used in quantitative research, factor analysis. We do so because factor analysis has different assumptions with respect to the approach we will show, which is more qualitatively oriented, and a comparison between these approaches is lacking from the literature. Thus, we use "real" data and we measure a concept frequently studied in social sciences using factor analysis and the three strategies based on fuzzy sets. We will see that the way concepts are built and measured impact on the empirical analysis. Eventually, we conclude.

2 Two Ontologies of Social Sciences: The Consequences on Concepts

Two ontologies dominate social sciences: the "quantitative" and the "qualitative" ones. The first generally refers to the variable-oriented approach, while the second concerns the case-oriented approach (Ragin and Zaret 1983; Mahoney and Goertz 2006; Tarrow 2004). Goertz (2006:2) argues that the lack of attention on concept formation derives from the traditional tension present in the social sciences between qualitative oriented scholars – particularly interested in concept and substantive issues – and quantitative oriented scholars – who, instead, are more concerned with scales, indicators and the production of reliable measures.[2]

The same distinction is applicable to concept formation approaches (Outhwaite: 1983). The "quantitative" approach to concepts stems from a critique of metaphysics and from its depreciation of language. Its main characteristics are that a) scientific theories must be constructed as a series of statements which build a system and they should be formalized in a scientific language, that is a syntax; that b) the use of a new formalized scientific language leads to a rejection of natural language; that c) there is a distinction between the good scientific language – that is, the logical one – and the bad scientific language, which is natural language. The aim is to find a neutral and

[2]We do not argue that the world of social sciences has sharp boundaries, but that this "classification" is a incomplete and approximate image of what the approaches to social sciences are (see Della Porta and Keating 2008). However, each classification imposes a distinction between "objects" for illustrative reasons. It undoubtely true that many quantitative scholars have interest in well defined and constructed concepts to be measured and that many qualitative scholars use measurement instruments to rank cases on scales. Nevertheless, this classification aims at discussing the differences between two ontological perspectives.

a-historical language which serves as a tool for theory building. Eventually, that d) it aims at a reduction of natural language to a neutral language which is empirical and, hence, grounded on experience.

The second position is the interpretive approach which is "anti-naturalist" (Mantzavinos 2005; Bevir and Kedar 2008). The argument of the anti-naturalists can be summarized in two points. The first is that there are differences between the concepts of scientific language and those belonging to social sciences. The second is that the concepts of social sciences are closer to those used in natural language than to those used by "hard" sciences. This means that the language of "hard" sciences is not adequate for social reality because their objects of study are completely different. This tradition opposes the view that the scientific language should be a reduction of the natural language and prefers an approach which privileges understanding and complexity. The importance of the anti-naturalist approach is that it incorporates in itself the idea of the contingency of social action and, more broadly, phenomena. Social reality is constituted by elements that cannot be described through the use of natural sciences categories (Bourdieu 2004).

Even concepts require a choice of ontology. A reflection upon the ontological nature of a concept allows the researcher to decide what is important about that concept, i.e. what its constitutive elements are (Goertz 2006:27). Choosing the attributes that are important for the construction of a concept requires the formulation of a theory about that concept. To put it differently, we need to define how the parts interact with the others and how the concept is causally connected to other concepts. In particular, the theory that is behind a concept allows understanding what the consequences of the concept structure are. The more-or-less relevance of an attribute may have effects on the secondary level dimensions of the concepts.[3]

The structure of a concept allows formulating hypotheses and building theories about other phenomena. For instance, the way we define and build the concept of political participation is important to the extent to which it helps us to understand how this is relevant for the concept of democracy (Diamond and Morlino 2005). Who claims that political participation is an essential part of democratic regimes without which they cannot be considered democratic (Dahl 1971; Dahl 1989) is building a theoretical statement that involves the attributes of the concept of political participation. If political participation is a necessary part of democratic regimes is because of its properties and the effects it has on this type of regimes.

3 Vagueness, Concepts and Fuzzy Sets

Natural and daily language allows constructing propositions, which describe objects, and producing generalizations about social reality. The problem is that natural language is often inaccurate and ambiguous. Some words may be imprecise or may have different meanings. Some other words may have limited applications. Some words can be "exceptional" in the sense that they have to be defined in time and space. A possible solution to the "imperfections" of language is their acknowledgement. An instrument

[3]For instance, Goertz (2006) uses the example of copper. This type of metal has an atomic structure that "produces" its reddish color, but we would be mistaken if we based the conceptualization upon this characteristic, which is the effect of the atomic structure and not a property itself.

that allows dealing with language uncertainty is fuzzy logic.

Fuzzy logic comes from the work of Lofti Zadeh (1965; 1988). He argues: "[m]ore often than not, the classes of objects encountered in the real physical world do not have precisely defined criteria of membership [. . .] the concept in question is that of a fuzzy set, that is a 'class' with a continuum of grades of membership" (1965:338–339).

Fuzzy logic differs from classical logic for five properties. The first is that in classical logic a proposition is either true or false. Conversely in fuzzy logic, the truth values are allowed to range over a fuzzy subsets of a set. The second is that the predicates in classical logic must be crisp "in the sense that the denotation of a predicate must be a non-fuzzy subset of the universe of discourse" (Zadeh 1965:338–339). In fuzzy logic the predicates are fuzzy, which means that they do not assume the values of 0 or 1, but they assume intermediate values. The third is that classical logic permits the use of just two quantifiers – all or some – while fuzzy logic allows the use of different quantifiers, such as most, many, several, much of, etc. The fourth is that fuzzy logic can represent the meaning of both non-fuzzy and fuzzy predicate-modifiers, such as not, very, extremely, a little. The fifth is that in fuzzy logic a proposition can be qualified by truth-qualification, probability-qualification and possibility-qualification.

As mentioned, everyday language uses words that may have imprecise meaning and that, therefore, can be "vague". When a concept is constructed with vague words it is almost impossible to define it clearly. However, vagueness is not necessarily a problem because: "[v]agueness, clearly, is a matter of degree, depending upon the extent of the possible differences between different systems represented by the same representation. Accuracy, on the contrary, is an ideal limit" (Russell 1923:90).

If concepts are built using the natural language, that is imprecise, they also are imprecise. Hence, it can be argued that natural language is fuzzy, in the sense that it does not distinguish between clearly defined objects, but it allows thinking in terms of membership degree (Lakoff 1973; 1987).

4 Applying Fuzzy Sets to Concepts

In the social sciences there are basically two logics of concept formation. One uses the AND logical operator (Sartori 1970, 1975, 1984) while the other – the "family resemblance" approach (Wittgenstein 1958; Collier and Mahon 1993) – uses the logical operator OR. The former looks for necessary and sufficient conditions, while the latter see the properties as sufficient or necessary elements of the concepts (Goertz 2006:74–75).

A simple example may help in understanding how concepts are not necessarily true or false, but can be partially true or false. Think of the word "red": "[i]t is perfectly obvious, since colours form a continuum, that are shades of colour concerning which we shall be in doubt whether to call them red or not, not because we are ignorant of the meaning of the word 'red', but because it is a word to the extent of whose application is essentially doubtful" (Russell 1923:85).

This quote shows that natural language is vague and, consequently, our knowledge is also vague.[4] Even though certain words may seem to have a precise meaning, such as the

[4]Russell warns the reader to not confuse the vagueness of the language with the vagueness of things. It

operators used in classical logic, the problem emerges when we try to draw inferences that, obviously, presuppose the use of truth and falsity. We know that the argument "p AND q" is true when p is true and q is true and it is false when either p or q are false. The problem with truth and falsity is that these two concepts are precise when the words we use are also precise. Hence, if we apply the concepts of truth and falsity to the construction of an argument, it follows that the extent to which we can determine the truth or the falsity of that argument will be more or less vague.[5] Nevertheless, classical logic assumes that the words employed are precise, and this has as consequence the fact that it may be inapplicable to the empirical world.

One of the most interesting characteristics of fuzzy set theory is that it allows approximating answers to questions that are based on a knowledge that is imprecise. Classical logic cannot solve the problem of approximation for two basic reasons: it is unable to represent the meaning of proportions that are expressed in a natural language; in case a language can be represented symbolically, classical logic does not provide a mechanism for inference. Fuzzy logic addresses these problems in two ways: "first, the meaning of a lexically imprecise proposition is represented as an elastic constraint on a variable; and second, the answer to a query is deduced through a propagation of elastic constraints" (Zadeh 1988:83).

A common instrument used by social scientists to build concept is the ideal-type (Goertz 2006:83). The ideal-type is a heuristic tool helping the researcher in solving a dilemma between using general concepts, which may not be useful for understanding what is important to select, and using specific concepts, i.e. those used by the historian, that are applicable to single instances. In Weber's words:

> An ideal-type is formed by the one-sided accentuation of one or more points of view and by the synthesis of a great many diffuse, discrete, more or less present and occasionally absent concrete individual phenomena, which are arranged according to those one-sidedly emphasized viewpoints into a unified thought construct. In its conceptual purity, this mental construct cannot be found empirically anywhere in reality. It is a utopia (1997:88).

Ideal-types have some advantages in concept formation. First of all, idealtypes allow the researcher to deal with complexity. Following Schmitter:

> I can see no viable alternative for us comparativists than to confront the messy and noisy world in which we live and design our theories accordingly.

should not be inferred that, since words are vague, the empirical world is vague in se. What he argues is that vagueness is not a property of an instance, but a characteristic of the relation between the instance and what is known. Although knowledge can be vague, this does not mean that we can say that an object is vague (1923:84–85). It would possible to say that vagueness is the product of the distance between what is known and the real properties of the objects. This distance may be reduced only if we make our knowledge more precise.

[5]The definition of vagueness is the following: "One system of terms related in various ways is an accurate representation of another system of terms related in various other ways if there is a one-one relation of the terms of the one to the terms of the other, and likewise a one-one relation of the relations of the one to the relations of the other, such that, when two or more terms in the one system have a relation belonging to that system, the corresponding terms of the other system have the corresponding relation belonging to the other system [...] Per contra, a representation is vague when the relation of the representing system to the represented system is not one-one, but one-many" (Russell 1923:89).

> And the place to start is by changing the basic concepts and classification systems that one needs to control for similarities and to identify differences. And the best tool for producing these building blocks is the 'ideal type' [. . .] comparative political analysis, if it is to remain significant, productive, and innovative in the future, has to reflect the 'real-existing'environment from which it should draw its observations and to which it should refer its findings (Schmitter 2009:45).

Second, they are useful to understand how an empirical case diverges from the pure case:

> Theoretically pure cases serve a heuristic purpose: they assist us in learning about and/or interpreting empirical cases on the basis of theoretical knowledge. The selection of ideal-typical cases is determined by our respective research objectives (Aus: 2009:176).

Third, they can be used in combination with fuzzy set theory (Kvist 1999; 2006; Goertz 2006; Schneider and Wagemann 2010). Applying fuzzy logic to ideal-typical concepts it is possible to understand cases as configurations of attributes that appear to different extents.

This allows studying and understanding the differences both in kind and degree that are present between the cases (Kvist 2006). It is also possible to apply fuzzy logic to the "radial categorical" structure of concepts (Collier and Mahon 1993), to establish the degree membership of the cases to concepts. The ideal-type is an appropriate tool because it forces the reseacher to find all the attributes of a concept, which do not have necessarily to exist in the real word, and it serves as a reference to compare cases.

The concept of democracy can be a good example to show that concepts are fuzzy. In the literature, the concept of democracy has been used both as dichotomous and as continuous (Collier and Adcock 1999). Following the first approach, a regime is either democratic or non-democratic (Przeworski et al. 2000), while using the second there is an assessment of the degree to which a case is democratic (Bollen and Jackman 1989).

Assume that country X is democratic. Naturally, one could ask: "How democratic does the country X need to be in order to gain the label 'democratic'?" A possible answer could be: "Country X is democratic if it has the characteristics A, B, C." The problem with this answer is that it implicitly uses a minimum to assess whether the features are present or not without considering the fact that some countries may have different levels of presence of those features. Country X has the features A, B, C, but also country Y has the features A, B, C, but to a different extent. Would you say that country X and country Y are instances of the same concept? Yes, they are instances of the same concept, but they are not democratic in the same way.

Lakoff makes a similar example in order to illustrate the idea of fuzzy concepts. He analyzes the statement "John is tall" and then he asks: "In contemporary America, how tall do you have to be to be tall?" (1973, 458). The examples may be very numerous. The substance is that we cannot apply the attribute of truth, falsity or nonsense to statements, because these statements are not entirely true, false or nonsensical. Therefore, the statement "Country X is democratic" is neither true nor false because the concept of

democracy does not have clear cut boundaries. Its boundaries are fuzzy, exactly because they are not defined.

An ideal-typical conceptualization allows avoiding conceptual stretching because there is a constant exchange with reality. There is the "archetypical" concept and there are the cases that are represented by different combinations and degrees of the attributes.[6]

5 A Configurational Approach to Concepts

Concepts are often the product of socio-historical configurations that do not always apply to the current problems we investigate. For this reason many concepts are very difficult to be abstracted from time and space to make them universally applicable. A way to overcome these problems is the idea of "composite concepts" (Bendix 1963). This kind of concepts has the property of being logically decomposable in attributes. As Bendix argues: "comparative sociological studies are needed to delimit the applicability of those attributes; here we are back to the space-and-time dimension of sociological concepts" (1963:534). Thus, the comparative approach is not only a method for inference, but also a method to understand the utility and, particularly, the validity of a concept.

Concepts should be seen as configurations of attributes, not just a sum of them. Concepts should be built understanding how the parts interact with each other, as concepts change depending on how the attributes are bound together. In other words, the way the attributes interact forms the concepts themselves. Thus, the attributes of a concept do not cause the concept, but they constitute it and the way the different attributes combine forms the concept.

The configurational approach to concept formation has a major advantage, that is to tackle the problem of the "gray zone" (Goertz 2006:29), namely the area in which it is not clear whether the case is a positive or negative instance of a concept. This perspective is very close to the "family resemblance" approach (Wittgenstein 1958; Collier and Mahon 1993) and to the "prototypical" or "archetypical" approach of the cognitive stream (Komatsu 1992). Applying fuzzy sets to concepts allows "solving", to a certain extent, the problem of the "gray zone" because depending on how we decide to structure a concept we deal with a different number of "gray cases" (Goertz 2006:119–120). Taking the maximum, the minimum or the sum of a number of dimensions, i.e. the structural components of a concept or attributes, does indeed make a difference because we choose between a minimalist or a maximalist concept structure.

Therefore, we define a concept through the identification of the attributes (Gerring 1999) which can be adjusted using a back-and-forth process (Ragin 1987; 2000; 2008) between the ideal-typical concept and social reality. In other words, there is a continuous dialogue between the concepts and the empirical data (Becker 1998) which allows the researcher to polish the incongruence between the theory and the empirical world.

[6]See Komatsu (1992) for a review on cognitive approaches to concepts.

6 Concept Structures and Fuzzy Sets

We argued that a concept is made of parts, but how do they relate with each other? A concept is such because it has a specific structure. The necessity and sufficiency structures reflect different ways of organizing the components of a concept. The necessity structure is based, in classical logic, on the operator AND or, in set theory, on the intersection, while it is based, in fuzzy logic, on the minimum criterion. Conversely, the sufficiency structure is based, in classical logic, on the operator OR or, in set theory, on the union, while it is based, in fuzzy logic, on the maximum criterion.

The attributes can be considered as sets. Therefore, an empirical case belongs to a configuration of attributes to the extent to which it belongs to the different sets (attributes) constituting the concept. Thus, a case should not be seen as an instance of a given concept, but as an instance of a configuration of attributes.

An example using set theory can be helpful: the concept of the "mother" (Collier and Mahon 1993), there are five attributes which are: female, provides 50% of the genetic make up, gives birth to the child, provides nurturance, married to the father. Therefore, in terms of sets we have (Partee et al. 1990):

$$F = def\{x|x \text{ is a female}\} \tag{1}$$

$$G = def\{x|x \text{ provides 50\% of the genetic make up}\} \tag{2}$$

$$B = def\{x|x \text{ gives birth to the child}\} \tag{3}$$

$$N = def\{x|x \text{ provides nurturance}\} \tag{4}$$

$$M = def\{x|x \text{ is married to the father}\} \tag{5}$$

There are five sets in which a person can be in or out. The configuration of sets to have the "true mother" is:

$$True\ mother = def\{F \cap G \cap B \cap N \cap M\} \tag{6}$$

A person, in order to belong to the set of the "true mother" must have all the characteristics:

$$True\ mother = def\{x|x \in F \cap x \in G \cap x \in B \cap x \in N \cap x \in M\} \tag{7}$$

To be a member of the set "genetic mother", the person just only needs to belong to the set "female" and to the set "provides 50% of the genetic make up":

$$F \cap G = def\{x|x \in F \cap x \in G\} \tag{8}$$

The intersection of all the sets produces the "true type" or the primary category of the concept, while the intersection of the set "female" with other sets gives us sub-types or secondary categories.

The use of the truth table can help in showing the different concept structures (Becker: 1998). Following the necessary attributes structure, we assume there is a concept Z which has four attributes or sets A, B, C, D, that are necessary in order to have the concept Z. Following the sufficient attributes approach, we assume there is a concept Z which has four attributes A, B, C, D that are sufficient in order to have the concept Z (see table 1).

The necessary attributes structure leads towards concepts which are, roughly said, pure types.[7] They are made of attributes that must be present in order to have an instance of that concept. These concepts can be "adjectified" by adding further attributes (Collier and Levitsky: 1997) which give different specifications to them. The sufficiency structure requires that at least one of its attributes is present. In fact, as Goertz states: "[t]he family resemblance concept structure is mathematically modeled by OR or the union in set theory" (2006:41).

There is a third approach, which we call "mixed", that uses both the logical operators AND and OR. The "mixed" structure allows showing what anecessary attribute is, that must be present in order to have a concept, and using a combination of other features specifying the concepts. By looking at table 1, we can notice that, in the "mixed approach" column A is a necessary condition, which combines either of B, C and D. Therefore, it allows multiple adjectives, which are not all necessary, but just sufficient. It should be noted that the attributes are part of the primary category of a concept (Collier and Mahon: 1993) and therefore the mixed structure is, practically, the radial category structure. However, it allows specifying the concept using combinations of attributes, not just one.[8]

[Table 1 about here]

Let us recall some foundations of fuzzy set theory. A fuzzy set A in X is a set in which the elements are characterized by a membership function which associates, for each point in X, a real number in the interval between 0 and 1 (Zadeh 1965:339–340). This function is: $f_a(x) = [0, 1]$. The union of two fuzzy set A and B which have as membership functions $f_a(x)$ and $f_b(x)$ is a fuzzy set Z which has the membership function $f_z(x) = Max[f_a(x), f_b(x)], x \in X$. The intersection of two fuzzy set A and B which have as membership functions and is a fuzzy set Z which has the membership function: $f_z(x) = Min[f_a(x), f_b(x)], x \in X$.

Table 2 shows how to combine attributes according to the necessity, the sufficiency and the mixed approach to concept formation using, instead of crisp scores, fuzzy scores. Doing so, we can indicate the extent to which a case is an instance of a specific concept. In fact, using fuzzy sets, idealtype/prototypical concepts should be seen as configurations of attributes (or fuzzy sets) in which each attribute scores 1 (Goertz 2006:84). Applying fuzzy logic to concepts we notice that in order to have an ideal-type none of the attributes must score under 1. Given that ideal-types do not have instances in the empirical world, we expect to find cases that are partial instances of an ideal-type.

The fuzzy logic approach to concepts has an important implication concerning the aggregation of the different levels of a concept. In order to aggregate the dimensions of a concept it should be born in mind the internal structure of the concept itself. A concept is mostly built up through necessary and sufficient structures. So, if the classical additive strategies of aggregation are used, it would not be possible to reproduce the same structure that a concept has.

[7] We do not use the word "pure" in the Weberian sense, but as a way to define a concept without further specifications.

[8] If features that are not within the primary category are added to the necessary attribute, we have the concept +/– adjectives structure (Collier and Levitsky: 1997; Goertz: 2006).

The risk of not considering the structure of a concept in aggregating its dimensions is having a measure that has a low level of consistency. If the attributes of a concept are connected with a series of AND's, an additive strategy of aggregation should not be used since it does not reflect the structure of that concept. In a few words, this is a logical, but not an additive strategy of aggregation of measures.

[Table 2 about here]

7 A Theoretical Application: The Concept of Political Participation

To show how to use fuzzy sets in concept formation we present a theoretical example. For this purpose, we use the concept of political participation. It can be argued that not all the forms of engagement are clearly positive of negative cases of the concept of political participation. There are forms of political action that may be part of the so-called gray area and for this reason it would be more appropriate to avoid a categorization approach based on classical logic and to use an approach based on partial membership to identify the "uncertain cases".

We rely on several definitions of political participation to build our concept (Verba and Nie 1972; Milbrath and Goel 1977; Verba et al. 1978; Barnes and Kaase 1979; Dalton 1988; Parry et al. 1992; Klingemann and Fuchs 1995; Norris 2002; Teorell et al. 2007).

In defining the concept of political participation we proceed in steps. We propose two different conceptualizations. A conceptualization encompassing the necessary attributes; a conceptualization including additional attributes specifying the previuos conceptualization.[9] Therefore, we define political participation:

> As an action characterized by the voluntariness of the action, i.e. the decision to do the action is taken by the individual with no external obligations; it has of a political aim, that is an action with the scope of changing or maintaining the existing reality; by it has a target, that is the object towards which the action is directed and whose decisions have an impact on the society.

Using fuzzy set theory, the membership function of the concept is:

$$Political\ action_{Necessary} = f_{Necessary}(x) \tag{9}$$

$$f_{Necessary}(x) = defMin[f_v(x), f_a(x), f_o(x)], x \in X \tag{10}$$

where $f_v(x)$ is the function defining the extent to which an action is voluntary, $f_a(x)$ is the function defining the extent to which an action has a political aim and $f_o(x)$ is the function defining the extent to which an action has an object. This concept of political participation is too broad to be useful. It should be considered as a first level of the concept, including necessary attributes to have a political action, but which are not sufficient.

The next step concerns the addition of a number of attributes. Hence, political participation is:

[9] See Goertz (2006:50–53) on conceptual levels.

an action which is voluntary, has an aim and a target. Furthermore, it is an action that can be declined through the use of a number of attributes, such as: salience, the extent to which the action has an impact; intensity, the extent to which the action requires physical energy; orientation, the extent to which the action is oriented to an aim/expression; cognition, the extent to which the action requires the use of cognitive resources; continuity, the extent to which the action is continuous over time; institutionalization, the degree of institutionalization; violence, the degree of violence that characterizes the action; agency, the extent to which the action is collective/individual; legality, the degree of legality of the action; resources, the extent to which the action requires material resources; structure, the extent to which the action is direct/ mediated by other actors; level, the extent to which the action is performed on a international/national/local level; nature, the extent to which the action is supportive/oppositive.

This conceptualization combines different characteristics of a political action producing a number of combinations that in most of the cases are real actions, although in other cases they may not exist.[10] The first level of the concept defines the pre-conditions to have a political action, the second specifies the action.

The way we combine the different attributes produces a concept of political action in which the different cases are part of this set to a different degree. This depends on the membership of the same cases to the sets, or attributes, which make up the concept. Table 3 shows how this definition would work using a truth table and few attributes.

For this example we use just four of the attributes for a matter of simplicity. The table is made of three macro-columns. In the first some political actions are listed. In the secondary level macro-column there are two types of attributes. The first are called necessary since without them it is impossible to give to an action the adjective "political". The second are called "additional attributes" since they specify the action, giving particular declinations to it. In the third macro-column we present four structures. The AND and the OR structures are the same as shown in the previous section. The other two structures highlight the importance of some attributes. The "mixed structure" A focuses on the legality of a political action and it is close to the definition of conventional political participation, while the "mixed structure" B focuses on the cognitive elements required by a political action. In fuzzy sets terms the membership function of a "legal" political action is:

$$Political\ action_{Legal} = def_{Legal}(x) \tag{11}$$

$$f_{Legal} = defMin\{f_l(x), Max[f_c(x), f_i(x), f_r(x)]\}, x \in X \tag{12}$$

While the membership function of a "cognitive" political action is:

$$Political\ action_{Cognitive} = defCognitive(x) \tag{13}$$

$$F_{Cognitive} = defMin\{f_c(x), Max[f_i(x), f_l(x), f_r(x)]\}, x \in X \tag{14}$$

[10]Similar to this is the problem of "logical remainders", which occurs in QCA. For more details, see Schneider and Wagemann (2006).

Where $f_l(x)$ is the function defining the extent to which an action is institutionalized, $f_i(x)$ is the function defining the extent to which an action is legal, $f_c(x)$ is the function defining the extent to which an action require cognition and, $f_r(x)$ is the function defining the extent to which an action require resources.

Fuzzy scores are obtained using "calibration" (Ragin 2000, 2008), which requires to choose the fuzzy scale to assign scores to the cases. For this example, we use a non-continuous fuzzy scale with six values: 0, .1, .4, .6, .9, 1. They indicate, respectively, that a case is fully out, mostly but not fully out, more or less out, more or less in, mostly but not fully in, fully in. This allows avoiding the problem of "grey cases", by taking a subjective decision.

[Table 3 about here]

Looking at table 3, we see that depending on how the attributes are combined we obtain different set membership scores, that are the configurations of attributes. For instance, voting, using the sufficient attributes approach (OR), belongs to the set of political actions with the score of 1, while using the necessary attributes approach (AND) the membership value drops to .1. Writing to a newspaper, using the OR structure, belongs to the set of political actions with the score of .9, while using the AND structure the membership score changes and it is .4. As far as the mixed structures are concerned, voting belongs to the set of legal action with a degree membership of 1,[11] while it belongs to the set of cognitive actions with the degree of .4. Writing to a newspaper belongs to the same extent to legal and cognitive political actions.

To conclude on this point, a fuzzy definition, for instance, of political participation requires the researcher to decide, first, the type of the structure of the concept, to choose, second, the fuzzy scale and, third, to assess qualitatively the membership of the action to the set. In fact:

> In a fuzzy set context, it is necessary for the investigators to decide (somehow) what objects are full members and nonmembers to anchor the scale. These objects should be included in the scaling task for subjects for two reasons. First, they provide anchors for the subjects and thus ensure that the assignments are valid. Second, a researcher's understanding may differ substantially from subjects', and the scaling task provides an opportunity to find this out! (Verkuilen 2005:477).

When a fuzzy set is constructed, we need to bear in mind that the universe of discourse must be clarified (Smithson and Verkuilen 2006). The more general the definition of the universe is, the more instances may fit into it, but also the more it would be difficult to establish the membership of that instance to the set.

In the case of political participation, the attributes of the concept should be considered as fuzzy sets, but the universe of discourse should not be taken as general. When we talk, for instance, of the individual/collective attribute of a political action, the attribute is not referred to any action, but to the type of instance that is the set of political actions. Thus, a strategy to avoid this problem is to specify the domain of reference of

[11] Voting could be considered the "ideal-type" of the legal political action.

the set we are using. This helps us in rendering the fuzzy concepts less fuzzy because we proceed in a systematical manner, so to reduce the natural fuzziness that we encounter using concepts that cannot be clearly specified or that do not have a common meaning.

8 An Empirical Application: The Concept of Support for Public Institutions

We now discuss a "real" example. The concept we use as example is "political support". The concept of political support represents one of the main interests of political science. Since the work by Easton (1965) and the "Trilateral Commission" Report (Crozier, Huntington and Watanuki 1975) the role of political support has been widely debated in the literature, as several scholars argue that it is fundamental for the legitimacy of democratic regimes.[12]

In this section we briefly conceptualize political support and the subconcept of support for political institutions following the several contributions present in the literature. Then we show how different conceptual structures lead to different measures of political support to demonstrate the consequences of the ontological choice we make about concepts, i.e. the choice regarding the structure. Eventually, we show the differences between the measures derived from different conceptual structures and factor analysis, and how some independent variables are differently associated with them using OLS models.[13] We do so because factor analysis treats the indicators as linearly dependent from a latent construct, producing scores weighted by the correlation coefficients between the indicators and the latent construct, while the measures obtained by the necessity, sufficiency and "mixed" concept structures are based on fuzzy logic.

The concept of political support is deeply debated in the literature. Several authors argue that the problem of this concept is that it is multidimensional (Levi and Stoker 2000), as it has several meanings and layers. It can be relational, evaluative, judgemental, affective, limited, conditional. Newton (2007:343) defines the general concept of trust, to which political support it strictly related, "as the belief that others will not deliberately of knowingly do us harm, if they can avoid it, and will look after our interests, if this is possible". Using the framework developed by Easton (1965), Dalton (2004:5–9) argues that is important to account for the different levels and objects of political support. Doing so, it is possible to include in a conceptualization the object of support and to define its generality/specificity. In fact, the general concept of political support include three levels: the political community, the regime and the political authorities. The second level of political support, the regime support, concerns attitudes towards the principle of a political regime, its norms and procedures, and its institutions. Being the institutions of a political system the partiament, political parties, justice courts, the law enforcement agencies and even supra-national institutions, we can say that support for political institutions regards the evaluative orientation towards a set of institutions regulating the public life in a political system.[14]

[12] See on the topic, among others, Klingemann and Fuchs (1995), Norris (1999), Pharr and Putnam (2000) and Dalton (2004).

[13] It would be also possible to use the measures as independent variables.

[14] The discussion on the meaning of political support is massive. In this section, we just outline a common

Having briefly defined the concept of "support for public institutions" a question comes in: in order to be a citizen supporting public institutions is it necessary to support them all, just one, or some of them? This question implies a conceptual structure and, therefore, a choice on how the elements of a concept relate to each other. This also affects the way we measure this concept and, therefore, it is very important during the stage of operationalization.

In order to illustrate how different conceptual structures produce different measures we make use of the British sample of the fifth release of the European Social Survey (2012). We use this dataset as it includes several indicators measuring support for public institutions. Among many, we select the indicators measuring support in national parliament, political parties, legal system, police, European parliament and the United Nations. The items range between 0 (low support) and 10 (high support).

Standard practice in the operationalization of support for public institutions implies the use of factor analysis to test the presence of one or more latent variables underlying this concept. Therefore, we apply this approach in the first place and then we compare it with measures derived from different conceptual structures.

The inspection of the eigenvalues of the correlation matrix of all the six indicators we selected tells that there should be one underlying dimension. Only one eigenvalue is higher than one, which is the threshold normally used to determine the number of factors in a factor analytic model. Therefore, a one-dimensional factor analytic model is tested. Table 4 reports the factor analysis results and the solution clearly shows that all the items load heavily on the hypothesized dimension and that the items explain about 55% of the variability of the latent construct. The Cronbach's alpha and the rho coefficients are about 0.90, which indicate hat the items have very high consistency and reliability. Since the presence of one dimension seems to be confirmed we compute the factor scores.

[Table 4 about here]

Although the measurement model reveals one underlying factor, some nuances are possible to be noticed. In fact, we think that three possible sub-dimensions exist:

- national political institutions
- national law enforcement institutions
- supra-national institutions

This distinction brings us to a choice which concerns the structure of a concept: do we need all the sub-components or not in order to identify a citizen supporting public institutions? Does a supporting citizen have to support national political institutions, law enforcement institutions and supra-national institutions? Or just some of them? In other words, how is the concept of support for political institutions built? Empirically, it has one underlying dimension but we need to make a choice about the structural features of this concept in spite of the correlation structure among the items.

conceptualization of political support in order to illustrate our argument.

We can outline three different conceptual structures.[15] The first is a "strict" conceptualization of support: a citizen shows support for public institutions if and only if he or she shows support in each institutions under study. Therefore, we use the "minimum" – AND structure – of the six items. The second is a "liberal" conceptualization of support: a citizen shows support in public institutions under study if he or she shows support in at least one institution under study. Therefore, we use the "maximum" – OR structure – of the six items. For the third we use a different approach, similar to the one used in the previous section. We use a "mixed" conceptual structure. In order to define as "supportive" an individual has to support three types of institutions: political, law enforcement, international institutions. Therefore, according to the "mixed" structure, to be a supportive respondent it is necessary to support at least one institution in each group of institutions. This structure is much easier to be understood using formal language. Being $f(x)$ the membership function of a respondent in an indicator (set) of support, we define the concept of support for political institutions as follows and we build the scores accordingly:[16]

$$f_{Support\ for\ Political\ Institutions}(x) = Max[f_{parliament(x)}, f_{political\ parties}(x)] \tag{15}$$

$$f_{Support\ for\ Law\ Enforcement\ Institutions}(x) = Max[f_{legal\ system}(x), f_{police}(x)] \tag{16}$$

$$f_{Support\ for\ International\ Institutions}(x) = Max[f_{european\ parliament}(x), f_{united\ nations}(x)] \tag{17}$$

$$f_{Support\ for\ Public\ Institutions}(x) = Min[f_{Support\ for\ Political\ Institutions}(x), \tag{18}$$

$$f_{Support\ for\ Law\ Enforcement\ Institutions}(x), \tag{19}$$

$$f_{Support\ for\ International\ Institutions}(x)] \tag{20}$$

Therefore, we get the maximum of "support for the parliament" and "support for political parties" membership scores to get the membership scores of "support for political institutions"; we get the maximum of "support for the legal system" and "support for the police" membership scores to get the membership scores of "support for law enforcement institutions"; we get the maximum of "support for European Parliament" and "support for United Nations" membership scores to get the membership scores of "support for international institutions". Then, we get the minimum of the three subscores. Doing so, a supporting citizen shows support if he or she supports each group of institutions. This means that we determine the structural relationship between elements using both necessity and sufficiency.

We can now compare the scores obtained using fuzzy logic and the three conceptual structures with the scores obtained with factor analysis, which are basically additive. To better illustrate the differences between the scores we graph their association in Figure 1 and report their correlation coefficients and distributions.

[15] Goertz uses the "substitutability continuum" (2006:44–46, 135–139) to show how the different components of a concept can be combined.

[16] We compute the three scores using fuzzy logic. However, we do not calibrate the scores to avoid modifying the distribution of the indicators. The scope here is to show how the different strategies to combine of indicators result in different measures. Therefore, we only transform the indicators in order to make them range between 0 and 1. Notwithstanding, we are well aware that calibration is a fundamental step of set-theoretic methods which requires the knowledge of the cases and the use of criteria external to the data (Schneider and Wagemann 2012:32–33). In this example we use survey data. For this reason, external criteria and knowledge of the cases are not possible to use the calibration of the scores.

We can see that the scores have a certain degree of similarity but they are not measuring the same thing. First of all, we can notice, by looking at the histograms, that the distributions of the scores are quite different. In fact, the means of the four scores built using factor analysis, the OR structure, the AND structure and the "mixed" structure are, respectively 0.44, 0.33, 0.70 and 0.40. Second, we can see that the scores built using factor analysis and the "mixed" structure have a bell-shaped distribution, while the other two are negatively and positively skewed.

[Figure 1 about here]

An individual with a high level of support on the OR structure measure may have a very low level of support on measure of support using the factor scores. If we compare the AND structure score with the factor scores we see that the two are much more similar, as well as the "mixed structure" scores and the factor scores. Despite the correlation coefficients indicate that the factor scores are moderately-to-highly associated with the three scores obained using fuzzy logic, we will see that the differences between scores become quite relevant when they are used as dependent variables.

We run four OLS models using the scores as dependent variables and including some independent variables that in the literature are commonly used to predict support for public institutions: gender (woman is the reference category), age in categories (¡ 26 as reference category, 26 – 35, 36 – 45, 46 – 55, 56 – 65, ¿ 65), education in three levels (low as reference category, middle and high), social trust (ranging from 0, low, to 10, high), satisfaction with life (ranging from 0, low, to 10, high), satisfaction with economy (ranging from 0, low, to 10, high), satisfaction with national government (ranging from 0, low, to 10, high), the left-right scale (ranging from 0, left, to 10, right) and the amount of time the respondents spend in watching political news on TV (ranging from 0, none, to 7, more than 3 hours a day).[17]

Table 5 reports the regression estimates for the four OLS models predicting the four scores of support for public institutions.

We also computed the predicted values for each model and we plot them Figure 2 to clearly show the association between the independent variables and the four scores.

[Figure 2 about here]

[Table 5 about here]

It can be noticed that depending on how we define and measure the concept of support for public institutions the importance of the independent variables varies substantially. For instance, only in the model using the AND scores as dependent variable the coefficient for the effect of being a woman is statistically significant and positive. In the models using the factor scores and the mixed scores models as dependent variables the coefficients are positive but not significant and in the last one, the OR scores model, despite non significant, the coefficient is negative.[18] Age is significantly associated with

[17] Factor scores are rescaled to range from 0 to 1 to make the regression coefficients to be comparable.

[18] We are well aware of the current debate on statistical significance arguing that mere significance does not imply substantial relevance (see, among others, Gelman and Weakliem 2009). However, for the matter of this example we talk of significant coefficient to show how the scores are differently associated with the independent variables.

three out of four dependent variables, while it is not associated with the OR scores model.

The estimates of education are positive in the models using the scores built with factor analysis, the AND structure and the "mixed" structure, while in the model using the OR scores as dependent variable the coefficients are not significant. Social trust is positively associated with all the four dependent variables, although sligthly differently as shown in Figure 2. Satisfaction with life has a stronger positive association with the OR scores, while less associated with the other scores. Satisfaction with economy and with the government present very similar associational patterns with the four scores, although the association with the OR score is weaker. The association between the left-right dimension and the four scores is statitically significant only in the OR scores model. Watching TV political news is positively associated with the four scores. However, the association with the AND score is not significant.

What Figure 2 cleary shows is that the main differences between the four models are not only the significance levels of the estimates, their magnitures or signs, but also their intercept values, which translate in difference predicted values. This depends on the fact that the four scores reflect different underlying concepts. The score based on the AND structure measures "strong" support, as it requires the respondent to have high levels of support in all the institutions. Conversely, the score based on the OR structure measures "weak" support, since it is enough to show support in at leat one institutions. The score based on the "mixed" structure requires the respondent to be supportive of at least one institutions whithin the three groups, so it represents a in-between solution compared to the previous ones.

But how to choose between different conceptual structures and consequent measures? There are two answers to this question. The first is "strictly" empirical. We can choose the score depending on the goodnessof-fit of the model which predicts it. It is well known that OLS models have to meet some assumptions. They concern the homoskedasticity, normality and independence of the residuals. Therefore, we can use regression diagnostic tests and plots as bases for our decision (see Fox 2008).

Figure 3 helps in detecting if the assumption of the homoskedasticity of the residuals is violated. It plots the fitted values of the models predicting the four measures of "support for public institutions" against the their standardized residuals. At a first sight, we can notice that a visible pattern between the each model fitted values and the standardized residuals is not present. In fact, it seems that all the four plots may resemble a null plot, meaning that a pattern is not present between fitted values and the standardized residuals. However, the quadratic fit lines indicate that there might be a curved trend in the data. Therefore, we use a common test, the Breusch-Pagan/Cook-Weisberg test, which assesses whether the variance of the residuals is constant or not. The test shows that the models predicting the dependent variables built using the AND concept structure and the OR concept structure present residuals that do not have a constant variance, meaning that the variance of the residual is a function of the predictors.

[Figure 3 about here]

Figure 4 shows the quantile-comparison plots of the studentized residuals for the models predicting the four dependent variables. It appears that only the residuals of

the model predicting the OR score do not follow a normal distribution. In fact, this is the only model in which the residuals clearly fall out the 95% simulated confidence intervals. It is also confirmed by the one-sample Kolmogorov-Smirnov test, which verifies that the residuals follow a normal distribution. The non-normality of residuals has as consequence that the standard errors may be biased. Hence, only for the other three models we can be sure that standard errors are correct, as the models do not violate the assumption of the normality of residuals.

The last assumption concerns the independence of the residuals. We use the Durbin-Watson test checks whether the models violate this assumption. Again, the test shows that the residuals of the model predicting the OR score are not independent.

These diagnostic checks tell us that the models predicting the factor scores and the mixed scores are the only ones which do not violate the three assumptions of OLS regression. Therefore, the choice will be between the models which predict two measures which are build starting from completely different conceptual structures.

[Figure 4 about here]

This means that we may need a second strategy, more focused on the test of a theory, to answer the question we posed earlier, as the "strictly" empirical strategy may be not sufficient to take a decision. Adcock and Collier (2001:542) propose, to validate a construct, a strategy called "Assume the Hypothesis, Evaluate the Measure". The principle of this strategy is "that scores which can validly be claimed to measure a systematized concept should fit well-established expectations derived from causal hypotheses that involve this concept". This means, in our case, that the researcher should test well established hypothesis concerning the association between a set of independent variables and the measures gauging different conceptual structures. If the well established hypothesis is confirmed, then the construct is valid.[19] The OLS estimates reveal that the variables predicting the four scores mostly confirm what a large body of literature has argued abou the determinants of political support in Western Democracies (Klingemann and Fuchs 1995, Norris 1999, Pharr and Putnam 2000, Dalton 2004). Therefore, it appears that the four scores, although measuring different conceptual structures, are valid constructs.

This empirical application clearly shows that the way we define a concept we use has important consequences on the analysis of the data. Building a concept means making a choice about its structure bearing in mind that this choice affects its measurement.

9 Conclusion

In this article we tried to outline a strategy for concept formation and operationalization. What we argued is that concept formation requires, first of all, a choice regarding the structural elements constituting the concept itself and a choice regarding the relation between elements. As shown, the way we build concepts affects the way we measure them, which has an impact on the empirical analysis.

[19] This, of course, implies the acceptance of the validity of the hypotheses. See Adcock and Collier (2001).

Another aspect we underlined in this article is that fuzzy set theory should be taken as a very useful instrument to understand how to build the concepts we use in our research. We tried to illustrate that fuzzy set theory has some advantages. The first is that it allows distinguishing the degree of membership of an object to a set. The second is that it provides a different logic with the respect of the classical one. Thanks to fuzzy set theory we can understand the extent to which an empirical instance is part of a concept, that is made of carefully selected attributes. Fuzzy set theory allows making the structure of the concepts explicit, avoiding imprecisions that are often encountered in definitions used, for instance, in the social sciences. Another advantage is that fuzzy set theory notation helps in defining the relation between the attributes. Often concepts are simply a list of attributes without a systematic reflection on how the parts of a concept bind together. As stated, behind a concept there is a theory and this strategy of concept formation forces the researcher to think about the problem of the structure.

To make our approach clear we presented a theoretical and an empirical example. The first aims at showing how to use fuzzy sets for concept formation. The second aimed at showing how fuzzy set can be used to measure concepts. We argued that different conceptual structures translate in different measures and they are critical for the subsequent analysis. In fact, we illustrated the nuances between four scores measuring the different conceptual structures underlying the concept of "support for political institutions" and their association with some standard predictors of this concept.

To conclude, we scope of the article was to show how to apply fuzzy set theory to a fundamental aspect of empirical research, that is concept formation and operationalization. Fuzzy logic is almost exclusively used as algorithm to minimize truth tables and, therefore, as a method for applied research (Schneider and Wagemann 2012). Conversely, in this article we showed that fuzzy logic can be a useful tool for formalizing the structures of social science concepts and for translating them in applicable measures.

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Table 1: Property space of a hypothetical concept Z using classical logic and three different concept structures

	Attributes — Sets				AND — Intersection Classical category	OR — Union Radial category	Mixed approach
Cases	A	B	C	D	$A*B*D*D \rightarrow Z$ $Z = def A \cap B \cap C \cap D$	$A+B+D+D \rightarrow Z$ $Z = def A \cup B \cup C \cup D$	$A*(B+C+D) \rightarrow Z$ $Z = def A \cap (B \cup C \cup D)$
1	1	1	1	0	0	1	1
2	1	1	1	1	1	1	1
3	0	0	1	1	0	1	0
4	0	0	0	0	0	0	0
5	1	1	0	0	0	1	1
6	0	1	1	0	0	1	0
7	1	1	0	0	0	1	1
8	1	1	1	1	1	1	1

Table 2: Property space of a hypothetical concept using fuzzy-sets and three different concept structures

	Secondary level				Basic-level Structures		
	Attributes — Sets				AND — Intersection Classical category	OR — Union Radial category	Mixed approach
Cases	A	B	C	D	$A*B*D*D \rightarrow Z$ $Z = def A \cap B \cap C \cap D$	$A+B+D+D \rightarrow Z$ $Z = def A \cup B \cup C \cup D$	$A*(B+C+D) \rightarrow Z$ $Z = def A \cap (B \cup C \cup D)$
1	1	.75	.75	.5	.5	1	.75
2	1	1	1	.75	.75	1	.75
3	.25	0	.75	.75	0	.75	.25
4	.5	.5	0	.5	0	.5	.5
5	.75	1	.25	.5	.25	1	.75
6	0	.75	1	0	0	1	0
7	.75	.75	.5	.5	.5	.75	.75
8	.75	1	1	.75	.75	1	.75

Table 3: The truth table for the concept of political participation

Actions	Secondary–level										Basic–level
	Necessary attributes			Additional attributes							Structures
	Voluntary	Aim	Object	Cogn.	Inst.	Res.	Leg. (A)	AND	OR	Leg. (B)	Cogn.
Voting	1	1	1	.4	1	.1	1	.1	1	1	.4
Squatting	1	1	1	.6	.1	.6	.4	.1	.6	.4	.6
Blogging	1	1	1	.9	.4	.6	.9	.4	.9	.9	.9
Residents association	1	1	1	.6	.6	.4	.9	.4	.9	.6	.6
Campaigning	1	1	1	.6	.9	.9	.9	.6	.9	.9	.6
Political party membership	1	1	1	.6	.9	.6	1	.6	.9	.9	.6
Writing to a newspaper	1	1	1	.9	.6	.4	1	.4	.9	.9	.9
Joining a Facebook group	1	1	1	.4	.6	.1	.6	.4	.6	.6	.4

Note: The degree memberships are arbitrary

Table 4: Factor analysis for the latent construct of "support for public institutions"

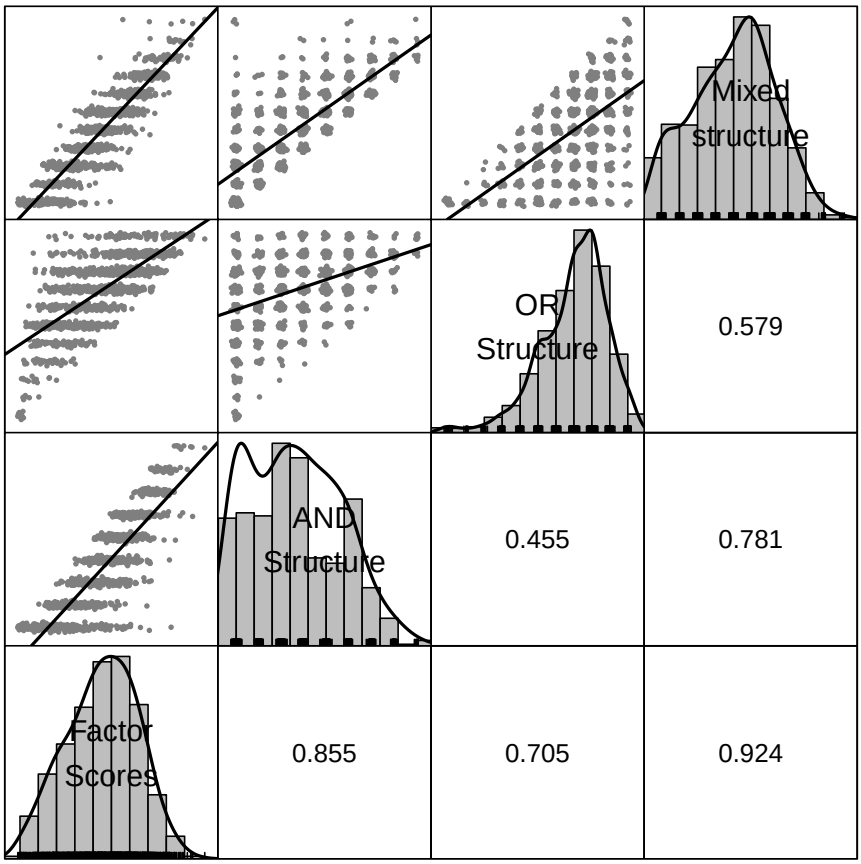
Factor	Loadings	Uniquenesses
Parliament	0.826	0.317
Political Parties	0.850	0.277
Legal System	0.700	0.511
Police	0.569	0.677
European Parliament	0.731	0.465
United Nations	0.698	0.513
N	1594	

Table 5: Ordinary Least Squares regression models predicting four scores, the OR scores and the Mixed scores, which measure dependent variables built using the Factor scores, the AND different structures of the concept of "support for public institutions"

	Factor scores model	AND scores model	OR scores model	Mixed scores model
(Intercept)	0.136***	0.034	0.416***	0.074**
	(0.023)	(0.032)	(0.025)	(0.028)
Gender: Woman	0.010	0.042***	-0.005	0.012
	(0.008)	(0.011)	(0.008)	(0.009)
Age: < 26				
Age: 26 – 35	-0.035*	-0.047*	-0.011	-0.035
	(0.016)	(0.023)	(0.018)	(0.020)
Age: 36 – 45	-0.035*	-0.047*	-0.017	-0.044*
	(0.016)	(0.022)	(0.018)	(0.020)
Age: 46 – 55	-0.042**	-0.055*	-0.015	-0.055**
	(0.016)	(0.022)	(0.017)	(0.019)
Age: 56 – 65	-0.046**	-0.082***	-0.026	-0.057**
	(0.016)	(0.022)	(0.018)	(0.020)
Age: > 65	-0.044**	-0.072**	-0.014	-0.057**
	(0.016)	(0.022)	(0.018)	(0.020)
Education: Low				
Education: Medium	0.033***	0.038**	0.015	0.036**
	(0.009)	(0.013)	(0.010)	(0.011)
Education: High	0.071***	0.084***	0.033**	0.080***
	(0.010)	(0.014)	(0.011)	(0.013)
Social trust	0.016***	0.020***	0.014***	0.014***
	(0.002)	(0.003)	(0.002)	(0.002)
Satisfaction with life	0.004*	-0.002	0.011***	0.004
	(0.002)	(0.003)	(0.002)	(0.003)
Satisfaction with economy	0.022***	0.033***	0.011***	0.022***
	(0.002)	(0.003)	(0.003)	(0.003)
Satisfaction with government	0.030***	0.028***	0.018***	0.033***
	(0.002)	(0.003)	(0.002)	(0.003)
LR-scale	-0.004	-0.009**	-0.001	-0.002
	(0.002)	(0.003)	(0.002)	(0.003)
Watch TV political news	0.009**	0.005	0.010**	0.008*
	(0.003)	(0.004)	(0.003)	(0.003)
R-squared	0.406	0.313	0.214	0.338
Deviance	34.306	67.150	42.009	52.203
N	1558	1558	1558	1558

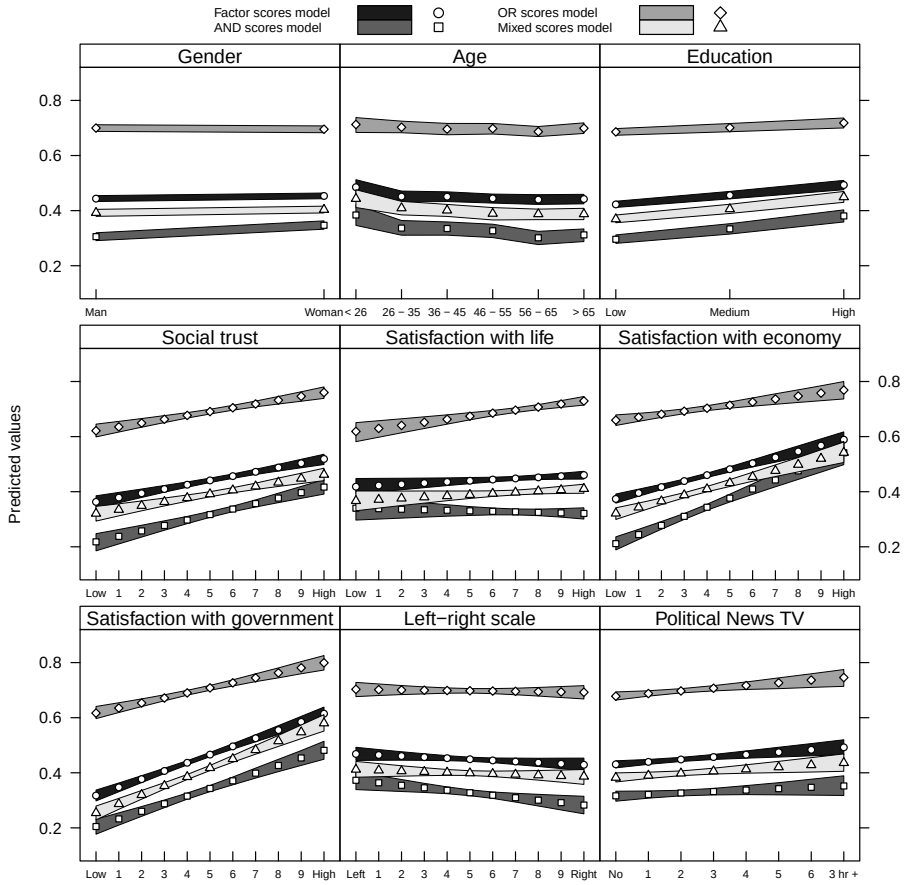
Note: standard errors in parentheses
* $= p \leq 0.05$; ** $= p \leq 0.01$; *** $= p \leq 0.001$
Source: own elaboration on ESS (2012)

Figure 1: Correlation matrix plot of scores measuring "support for public institutions"



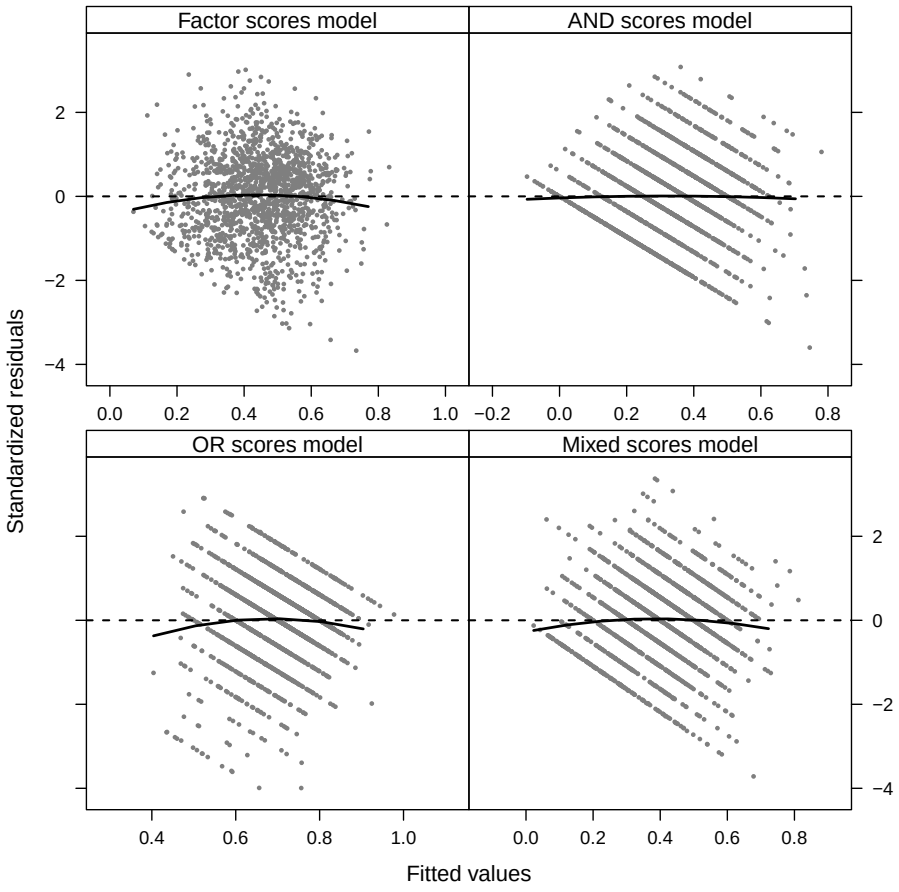
Note: scores constructed using factor analysis, the AND conceptual structure, the OR conceptual structure and the mixed conceptual structure. Scatter plots between the four scores are reported in the upper triangle of the plot, with fit lines (random noise is added to improve clarity). Correlation coefficients between the four scores are reported in the lower triangle of the plot. In the diagonal the histograms and the relative kernel density lines describing the distribution of the four scores are reported. All scores range between 0 and 1.

Figure 2: Association between independent variables and the predicted values of variables measuring "support for public institutions"



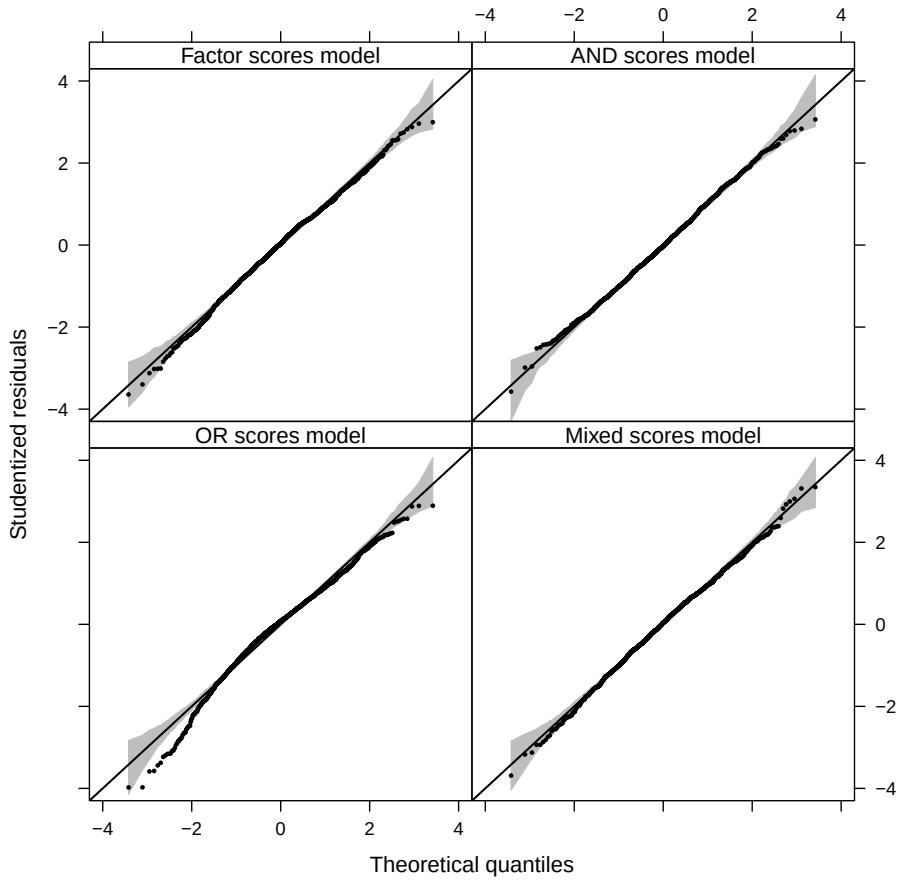
Note: With 95% simulated confidence intervals. Based on the estimates reported in Table 5. Predicted values are calculated holding the variables at their means.

Figure 3: Residual plots for the models predicting the four variables measuring "support for public institutions"



Note: The solid black line is a fitted quadratic regression of the residuals on the fitted values.

Figure 4: Quantile-comparison plots of studentized residuals from models predicting four variables measuring "support for public institutions"



Note: with 95% simulated confidence intervals.