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A fuzzy-hybrid analysis of citizens' perception toward immigrants in Europe

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Abstract
The public and political debate about immigration now play a big role in all European elections, and there is a trend increasing an anti-immigrant sentiment that receives important media attention. This work, based on the European Social Survey (ESS) round 9 data for 27 European countries, contributes to such debate by introducing a new method in the field, a Fuzzy-Hybrid Approach (FHA), that complements other methodological methods that have been used to measure citizens' attitudes towards immigrants. The novel approach in the field provides a synthetic indicator that measures openness towards immigrants (OTISI). Then, we analyse the relationship that exists between some specific sociodemographic variables and the new index. Results show that country, political orientation, age, religion, economic situation, gender, birthplace, employment, education, universalism, and conformity are key drivers that explain different attitudes towards immigrants. Our findings concur with other previous studies showing that the results are robust and that the method can be applied in future social science studies.

Keywords Immigration · European Social Survey · Fuzzy-Hybrid Approach · TOPSIS

1 Introduction

The latest migration waves and the new refugees' crisis have developed an increasing interest in the public and academic debate (Azrout et al. 2011; Esses 2021; Kusow and DeLisi 2021). Confirmatory Factory Analysis (CFA) and the Structural Equation Model (SEM) have up to now been valid and significant approaches for the study of attitudes towards immigrants. These methods are based on a measurement model in which latent variables are obtained through an econometric model adapted to the observed elements (Meuleman and Billiet 2012; Semyonov et al. 2006; Sønderskov and Thomsen 2015; Thomsen and Rafiqi 2018).

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Despite the increased scientific contributions on the topic, the methodology does not seem to make any significant progress in the field. To our surprise, the implementation of other quantitative approaches, such as Data Envelopment Analysis (DEA) and Fuzzy Hybrid Approach (FHA), has been scarcely used in the field. Nevertheless, these methods present several advantages over other traditional econometric models (Martín and Indelicato 2021). Furthermore, Kentmen-Cin and Erisen (2017) recommended, assessing critically previous research on attitudes towards immigrants and their relationship with EU attitudes, the use of other quantitative methods and designs to deepen the understanding of the relationship.

Furthermore, current literature on ATI suggests that anti-immigrant sentiment is affected by both individual-level and country-level factors (Davidov et al. 2020). The principal factors analysed at individual level are socio-economic position (Coenders and Scheepers 2003; Gorodzeisky 2011; Kunovich 2004; Raijman et al. 2003; Semyonov et al. 2008), political orientation (Semyonov et al. 2006) and individual human values (Beierlein et al. 2016; Sagiv and Schwartz 1995; Schwartz 2006; 2007). In addition, at the country level, some authors focus on some society structural attributes, such as immigrant population and country integration policies (Kuntz et al. 2017; Schlueter et al. 2020).

Thus, the study has two main aims: (1) to extend the current literature on attitudes towards immigrants, introducing a novel approach in the field based on a Fuzzy-Hybrid Approach (FHA) to obtain an openness towards immigrants' synthetic indicator (OTISI). The synthetic indicator is based on six different items that proxy the ethnic, economic, cultural, and religious threats; and (2) to analyse how OTISI is influenced by sociodemographic variables, such as country, political orientation, age, religion, economic situation, gender, birthplace, employment, education, universalism, and conformity. For the empirical analysis, data are extracted from the European Social Survey (ESS) round 9, and the analysis of the openness towards immigration is carried out for 27 European countries.

The paper complements other studies (Bail 2008; Capelos and Katsanidou 2018; Davidov et al 2018; Heath and Richards 2020) using a novel approach in the field that has not been commonly used. Thus, our study will serve to analyse whether the results are robust and to propose a novel quantitative method based on fuzzy logic as a fruitful expansion that can be used in social science for the future research agenda proposed by de Vreese (2017) regarding: (1) the differentiation in EU attitudes towards immigrants; (2) the role of national political elites; (3) the changing communications environment; and (4) the role of religion and religious attitudes.

2 Literature review

2.1 Theoretical background

Recent ISIS terrorist attacks in Europe have intensified fear sentiments among native populations and immigrants (Mancosu and Ferrín Pereira 2021). Several scholars concluded that the dynamics of intolerance and the perception of immigrants as a threat were the results of the created tensions after the 9/11 attacks, the 2004 bombings in Madrid, London 2005, Charlie Hebdo 2015, and Paris 2018 (Miguel-Tobal et al. 2006; Bar-Tal et al., 2012; Huddy et al. 2005; Skitka et al. 2004; Ben-Ezra et al. 2015; Vasilopoulos et al. 2018).

Many researchers have analysed the identity aspects of opinions towards immigrants (Azrout et al. 2011; Davidov and Semyonov; 2017; de Vreese 2017; Esses

2021; Kusow and DeLisi 2021). Azrout et al. (2011) argued that the key component to negative attitudes towards immigration is rooted in the consideration that immigrants are "different". Furthermore, McLaren and Johnson (2007) explained that the negative sentiment towards immigrants was more evident in those populations where the number of immigrants is more relevant. In this context, Claassen and McLaren (2021) found that the increase in immigrant arrivals from Muslim countries caused a galvanization of authoritarian anti-immigrant behaviour.

Barnum and Sullivan (1989) defined intolerance as the main element of the anti-immigrant sentiment. Nelsen and Guth (2003) argued that social diversity fuels the negative relationship between intolerance and anti-immigration attitudes. Within this context, Claasen and McLaren (2021) found that anti-immigrant attitudes varied when the immigrants are culturally distant using an experiment fielded in the seventh round of the ESS. The experiment was designed to analyse the effects of the economic and cultural/identity threats that significantly contribute to the rhetorical immigration political discourse. Kentmen-Cin and Erisen (2017) showed that intolerance and perceived threats by immigrants are associated with the escalation of far-right parties.

Social diversity intolerance is also influenced by culture. For example, Yavcan (2013) highlighted that Europeans tend to be more open towards European immigrants than non-European immigrants. Thus, countries with a higher percentage of immigrant populations, which are culturally diverse, appear to show more intense opposition to immigration (Tillman 2013).

In this context, Erisen and Kentmen-Cin (2017) analysed the citizens' perception towards Muslim immigrants in the Netherlands and Germany, finding that, in the Netherlands, citizens are significantly more intolerant towards Muslim immigrants than Germans, as Germans are more used to these immigrants. The authors also found that fear and anger have always increased intolerance and fuelled the perception of immigrants as a threat.

Other studies have analysed ATI from the perspective of the symbolic threat (traditions, religion, culture, and social norms). The literature distinguishes immigration threats through their nature and intensity (Canetti-Nisim et al. 2008). Many scholars affirm that anti-immigrant attitudes are driven by economic situations, security issues, cultural and religious principles (Chandler and Tsai 2001; Citrin et al. 1997; Espenshade and Calhoun 1993; Sniderman et al. 2004; Stephan et al. 1999). In addition, these different types of threats find a different manifestation according to the sociological characteristics and individuals' ideological sensitivities (Ceobanu 2011).

On the other hand, the perception of threat can be a consequence of a vulnerable economic situation, that is often interconnected to nationalism, ethnic conditions of the host country and society (Blalock 1967; Blumer 1958; Bobo and Hutchings 1996; Hainmueller and Hopkins 2014; Heath and Tilley 2005; Meuleman et al. 2018; Scheepers et al. 2003; Scheepers et al., 2003). Other researchers affirm that symbolic threat intensifies the fear of losing cultural homogeneity within the group and national identity of the host society (Fetzer 2000; Raijman et al. 2008; Raijman and Semyonov 2004; Sniderman et al. 2004). Dennison and Geddes (2019) contended that immigration affects individuals very differently and that some features could threaten conservative values such as safety, tradition, or conformity. They also warned policymakers and analysts to not cross the soft line that equates negative ATI with racism or xenophobia. Thus, the authors called for a better understanding of ATI's drivers and structure.

2.2 Explanatory variables

This section will cover the main explanatory variables that have been used as ATI's predictors. The analysis will be based on individual and country-level covariates. For obvious reasons, we will highlight here the covariates used in the study, such as political orientation, age, religion, income, gender, citizenship, main activity, and education for the group of sociodemographic variables; and universalism and conformity/tradition for the group of human values. Regarding the country-level covariates, our study is only based on the country variable itself, but, we will summarize, in this case, other types of variables that have been used, such as immigration policy, economic trends, and foreign population.

2.2.1 Individual covariates

Ceobanu and Escandell (2010) found that citizens' political orientation plays a determinant role in explaining ATI. The authors based their analysis on the left–right political orientation. McAllister (2018) claimed that right-wing citizens tend to express more negative ATI than left-wing counterparts. In general, right-wing voters see immigrants as an excessive burden to western social welfare states. The effects of age on ATI seem to point out that, in general, older people tend to have more negative ATI than the young generations (Brenner and Fertig 2006). As we will see below, this is also related to the fact that young people tend to be more universalists than their parents' generation, although this result is contested by Heath (2020). The authors argued that the youngest generations can be highly affected in territories in which the far-right wing parties have got a strong relevance during their formative years.

Social and national identity are mainly identified by birthplace, ancestry, religion, language, and institutional-laws respect (Fussell 2014). Ceobanu and Scandell (2010) claimed that researchers are reluctant in exploring the relationship between religion and ATI. Religion has been studied in ATI contexts for some particular cases, such as anti-Muslim prejudice (Hainmueller and Hopkins 2014; Schlueter et al. 2020). In this case, the authors found that some country-level variables, such as liberal integration policies and state support for religious freedom, are both associated with a lower level of negative ATI. Regarding income, previous studies agreed that high-income citizens usually hold more positive ATI (Coenders et al. 2008; Kuntz et al. 2017). A similar explanation for education is also valid here.

Fussell (2014) claimed that gender has been a common predictor used to analyse ATI but, unfortunately, the obtained relationship is not conclusive. Thus, it is possible to find studies that point out three distinct results: (1) women are more open towards immigrants than men; (2) men are more open than women; and (3) there is not a significant difference between men and women. Citizenship depends on the birthplace in many countries, and it is usually highly associated with social and national identity formation (Heath and Tilley 2005). In general, previous studies have found that native-born citizens are less open towards immigrants than foreign-born citizens (Raijman et al. 2008). However, Fussell (2014) affirmed, in the case of the USA, that the relationship between ATI and the native-born variable might be biased because the in-group conceptualization was mainly based on non-Hispanic Whites.

Previous studies agreed that native-born unemployed citizens tend to exhibit more negative ATI (Brenner and Fertig 2006; Fussell 2014). Fussell (2014) argued that the cause that

explains this finding is mainly based on the self-interest hypothesis, in which unemployed citizens do not want to compete in the labour market with immigrants. Regarding education, there exists an ample consensus, the more educated a citizen is, the more open towards immigrants is (Hatton 2020). In this context, Brenner and Fertig (2006) contended that education was found to be one of the most important drivers that explain ATI. This finding is usually explained because education provides citizens with better labour opportunities that make them less likely to compete in the labour market with low-skilled immigrants.

The analysis of human values will end the individual covariates. Several studies have shown that human values are important drivers to analyse ATI (Beierlein et al. 2016; Sagiv and Schwartz 1995; Schwartz 2006). For example, Beierlein et al. (2016) found that universalist people tend to express lower levels of symbolic threat. On the other hand, it turns out that people associated with conservative beliefs feel the instinct to protect the customs and the traditions of the society, so the values associated with conformity and tradition explain, in part, the negative ATI (Sagiv and Schwartz 1995).

2.2.2 Country-level covariates

ATI multi-country survey projects have fostered the use of variables at the country level (Ceobanu and Escandell 2010). The country variable can be used to compare ATI in different countries because the immigration scales developed from multiple items have been rigorously checked by Davidov et al. (2018). In Europe, a well-known result, obtained in the past analysing ATI at the country level, is that there are two differentiated areas: Eastern countries with more negative ATI than Western and Nordic countries (Bail 2008; Heath and Richards 2020). Other country-level variables to proxy country idiosyncratic features include immigration policy, the volume of immigrants, and the economic situation measured as GDP evolution or unemployment rate.

The literature review contextualizes the study and ends with its two main hypotheses: (1) the novel approach in social science, FHA, based on fuzzy set theory is an adequate quantitative method that provides a soundness openness towards immigrants' synthetic indicator (OTISI); and (2) results offer a complementary and robust vision of what is already known, such as left-wing, young, highly educated and universally inclined citizens are more open towards immigrants than a right-wing, old, uneducated and traditionalist citizen.

3 Data

Data for this study are extracted from European Social Survey (ESS). ESS is undoubtedly a good source of measurement scales related to citizens' immigration attitudes (Messing and Ságvári 2018). Here, we analyse a set of 27 countries that have participated in round 9 of the ESS, with a total sample size of 47,086 respondents. We examine the answers given to six questions included in the questionnaire as primary information to measure OTISI in Europe (Table 1). The first block concerns questions regarding opposition to immigration. That is: (1) "To what extent do you think [country] should allow people": (a) of the same race or ethnic group as most people from [country] to come and live here? '[variable: imsmetn (C1)]; (b) "of a race or ethnic group other than most [country] people to come and live here?" [Variable: imdfetn (C2)]; (c) "from the poorest countries outside Europe to come and live here?" [Variable: impcntr (C3)]. It can be seen that for these first three items

Table 1 Openness towards immigrants' scale

C1. Allow none/many immigrants of same race/ethnic group as majority	Semantic 4-point ordinal scale[a]
C2. Allow none/many immigrants of different race/ethnic group as majority	Semantic 4-point ordinal scale[a]
C3. Allow none/many immigrants of poorer countries outside Europe	Semantic 4-point ordinal scale[a]
C4. Immigration is bad or good for country's economy	Semantic 11-point ordinal scale[b]
C5. Country is a worse or better place to live by immigrants	Semantic 11-point ordinal scale[b]
C6. Country's religious beliefs and practices are undermined or enriched by immigrants	Semantic 11-point ordinal scale[b]

[a](1). Allow none; (2) Allow a few; (3) Allow some; (4) Allow many [b] (1). Bad, worse or undermined – (11) Good, better or enriched

(allowing immigrants from the same race/ethnic group; allowing immigrants from a different race/ethnic group, and allowing immigrants from poorer countries outside Europe), the answers are based on a four-point semantic ordinal scale in which one means none; two (a few); three (some) and four (many). Originally, the answers are given in a reversed scale as (1) allow many to come and live here; (2) Allow some; (3) Allow a few; and (4) Allow none. The reverse scale was obtained due to the interest in measuring the openness to immigration. As discussed in the theoretical background section, these three items are related to economic and symbolic threats.

The three additional questions included in the second block measure the effects of immigration on the economy [variable: imbgeco (C4)]; the living conditions of the country [variable: imwbcnt (C5)]; the cultural life [variable: imueclt (C6)]. In this case, the raw data range from 0 to 10, and we decide to transform the scale into 1 to 11, as the answer already has a direct relationship with the openness to immigration no further transformation was needed. The last three items are referred to the effects of immigration on the economy, living conditions, and religious beliefs and practices of the host country. In this case, the questionnaire uses an eleven-point semantic scale anchored in the extremes with the following wordings bad vs. good; worse vs. better and undermined vs. enriched. Since the individual items provide only a partial and contrasting view of the phenomenon of immigration, we will propose a method to calculate a composite indicator (OTISI) using all items as components.

Table 2 shows the covariates included in the dataset to analyse OTISI on different population segments, such as country, political orientation, age, religion, income, gender, citizenship, main activity, universalism, traditionalism, and education. The raw data were recoded according to the interest of the research. The whole explanation for the recoding process could be consulted in Annex 1. The relationship between OTISI and the covariates used in the study was previously discussed in the section of individual covariates.

Table 3 presents the descriptive statistics of the sample, showing the number of respondents and percentage for each category analysed. Results can be summarised as follows: Austria, Germany, Czechia, and Italy present more than 5 per cent of the total sample. Liberals (Centre) are over-represented with 44.6 per cent. Moreover, the sample is more represented by citizens older than 56 years old. On the other hand, the least represented group is that of those who are younger than 26 years old. Regarding religion, the sample is predominantly Christian (55.7%), follows by agnostics (40.2). The sample is also characterized by citizens who feel that the household income is adequate to pay the bills –as 76% think that

Table 2 List of covariates included in the analysis

Description	Item	Wording	Response category
Country	Cntry	Country	Austria (1); Belgium (2); Bulgaria (3); Switzerland (4); Cyprus (5); Czechia (6); Germany (7); Estonia (8); Spain (9); Finland (10); France (11); United Kingdom (12); Croatia (13); Hungary (14); Ireland (15); Italy (16); Lithuania (17); Latvia (18); Montenegro (19); Netherlands (20); Norway (21); Poland (22); Portugal (23); Serbia (24); Sweden (25); Slovenia (26); Slovakia (27)
Political Orientation	lrscale	Placement on left–right scale	Left (0–1); Centre-Left (2–3); Centre (4–6); Centre-Right (7–8); Right (9–10)
Age	agea	Age of respondent	25 years or under (1); 26–35 years (2); 36–45 years (3); 46–55 years (4); 56–65 years (5); 66–75 years (6); and 76 years or over (7)
Religion	rlgdnm	Do you consider yourself as belonging to any particular religion or denomination?	Roman Catholic (1); Protestant(2); Eastern Orthodox (3); Other Christian denomination (4); Jewish (5); Islamic(6); Eastern Religion (7); Other non-Christian religions (8)
Income	hincfel	Feeling about household's income nowadays	Living comfortably on present income (1); Coping on present income (2); Finding it difficult on present income (3); Finding it very difficult on present income (4)
Gender	gndr	Gender	Male (1); Female (2)
Citizenship	brncntr	Citizenship	Born in the country (1); Foreign-born (2)
Main activity	mnactic	what you have been doing for the last 7 days?	in paid work (1); in education (2); unemployed and actively looking for a job (3); unemployed, wanting a job but not actively looking for a job (4); permanently sick or disabled (5); retired (6); in community or military service (7); doing housework, looking after children or other persons (8); other (9)
Universalism	ipeqopt	It is important that people in the world are treated equally and have equal opportunities in life	Not like me at all(1); Not like me (2); A little like me (3); Somewhat like me (4); Like me (5); Very much like me (6)
	ipudrst	It is important to listen to people who are different from us even if we disagree with them, we still want to understand them	Not like me at all(1); Not like me (2); A little like me (3); Somewhat like me (4); Like me (5); Very much like me (6)
Conformity/Tradition	ipfrule	It is important to do what is told and follow rules at all times, even when no one is watching	Not like me at all(1); Not like me (2); A little like me (3); Somewhat like me (4); Like me (5); Very much like me (6)
	ipmodst	It is important to be humble and modest, and not draw attention	Not like me at all(1); Not like me (2); A little like me (3); Somewhat like me (4); Like me (5); Very much like me (6)

Table 2 (continued)

Description	Item	Wording	Response category
	ipbhprp	It is important to behave properly and avoid doing things people would say are wrong	Not like me at all(1); Not like me (2); A little like me (3); Somewhat like me (4); Like me (5); Very much like me (6)
	imptrad	It is important to follow traditions and customs handed down by religion or family	Not like me at all(1); Not like me (2); A little like me (3); Somewhat like me (4); Like me (5); Very much like me (6)
Education	eisced	Highest level of education completed	Less than lower secondary (1); Lower secondary (2); Lower tier upper secondary (3); Upper tier upper secondary (4); Advanced vocational, sub-degree (5); Lower tertiary education, BA level (6); Higher tertiary education, ≥MA level (7)

Table 3 Respondents' profile

Label Country	N	Percent	Label Country	N	Percent
Austria	2499	5.3	Ireland	2216	4.7
Belgium	1767	3.8	Italy	2745	5.8
Bulgaria	2198	4.7	Lithuania	1835	3.9
Switzerland	1542	3.3	Latvia	918	1.9
Cyprus	781	1.7	Montenegro	1200	2.5
Czechia	2398	5.1	Netherlands	1673	3.6
Germany	2358	5	Norway	1406	3
Estonia	1904	4	Poland	1500	3.2
Spain	1668	3.5	Portugal	1055	2.2
Finland	1755	3.7	Serbia	2043	4.3
France	2010	4.3	Sweden	1539	3.3
United Kingdom	2204	4.7	Slovenia	1318	2.8
Croatia	1810	3.8	Slovakia	1083	2.3
Hungary	1661	3.5			
Label Political Orientation	N	Percent	Label Age	N	Percent
			25 years or under	3087	6.6
Left	2744	5.8	26–35 years	4919	10.4
Centre-Left	6449	13.7	36–45 years	6723	14.3
Centre	20,995	44.6	46–55 years	7541	16.0
Centre-Right	7200	15.3	56–65 years	8341	17.7
Right	2562	5.4	66–75 years	8280	17.6
			76 years or over	7973	16.9
Label Religion	N	Percent	Label Household income	N	Percent
Christian	26,250	55.7	Comfortably	13,975	29.7
Jewish	39	0.1	Coping	21,637	46.0
Islamic	1378	2.9	Finding it difficult	7896	16.8
Other	345	0.7	Finding it very Difficult	2905	6.2
Agnostic	18,938	40.2			
Label Gender	N	Percent	Label Place of birth	N	Percent
Male	21,753	46.2	Born in the country	42,394	90.0
Female	25,333	53.8	Foreign-born	4667	9.9
Label Unemployed	N	Percent	Label Universalism	N	Percent
Paid work	23,308	49.5	Not like me at all	12,873	27.3
Student	3236	6.9	Like me	20,072	42.6
Unemployed	2431	5.2	Very much like me	12,705	27.0
Retired	13,080	27.8			

Table 3 (continued)

Label Unemployed	N	Percent	Label Universalism	N	Percent
Other	4871	10.3			
Label Conformity/traditions	N	Percent	Label Education	N	Percent
Not like me at all	11,538	24.5	Less than lower secondary	3702	7.9
Like me	23,098	49.1	Lower secondary	7880	16.7
Very much like me	10,499	22.3	Lower tier upper secondary	7546	16.0
			Upper tier upper secondary	11,009	23.4
			Advanced vocational, sub-degree	5806	12.3
			Lower tertiary education, BA level	4963	10.5
			Higher tertiary education, ≥ MA level	5918	12.6

the situation is comfortable. In contrast, six per cent of the sample find it very difficult. The sample is slightly more represented by women (53.8) than by men (46.2). Only ten and five per cent of the sample were born in a foreign country and are unemployed, respectively. Fifty per cent of the sample receive a salary and 28 per cent are retired. And finally, regarding education, it can be seen that 22 per cent of the population are highly educated, meanwhile, those whose studies are less than lower secondary drop to eight per cent. The next section will detail the FHA.

4 Methodology

The six items included in the questionnaire that measures the openness attitude towards immigrants use semantic ordinal scales. The semantic ordinal scales are, in general, used to collect intrinsically vague information (Marasini et al. 2016). In our case, it is evident that if respondent A answers that she wants to accept many immigrants and a respondent B responds, on the other hand, that he wants to admit only a few immigrants, it is reasonable to agree that respondent A is more open towards immigrants than respondent B. The discrete semantic ordinal scales are similar to Likert scales that are also commonly used in social science in which the judgments made by respondents are usually seen as equidistant crisp numbers. In this case, respondents provide a set of statements with a positive or negative connotation regarding the phenomenon under study, and they evaluate them according to the following format: (1) strongly disagree; (2) disagree; (3) uncertain; (4) agree; and (5) strongly agree. For example, the ESS could have used the Likert scale for imbgeco with the following question: Immigration is good for the country's economy.

The complex steps involved in the mental process that respondents use to answer the questionnaire, undoubtedly, pose the base to ascertain that, in most of the cases, the information provided is uncertain or vague, as is the case for the eleven-point ordinal scale used in the survey. Thus, the information provided by respondents in the immigration scale is not so precise as the information provided by other categorical variables such as age, religion, or political orientation.

According to Smithson and Verkuilen (2006), "many concepts in the social sciences contain essential vagueness in the sense that while we can define prototypical cases that fit the definition, it is not possible to provide crisp boundaries between sets […]. The fuzzy set theory provides a mathematical toolbox for analysing situations like this with precision, not via a definite cut-off, but by defining a degree of membership between the qualitatively different state" (Smithson and Verkuilen 2006, pp. 6–7). Fuzzy Set Theory (FST) is not only appropriate to adjust the vague information provided by ordinal semantic scales but also to develop mathematical models that resolve many different empirical applications in many fields, such as the tourism or hotel industry (Kumar 2019; Martín et al. 2019), education (Di Nardo and Simone 2019), supplier selection (Rashidi and Cullinane 2019), green energy (Mohsin et al. 2019). The essence of the application of the FST resides in that there is not a unique objective function that exists to measure latent concepts that are common in social science (Martín et al. 2019). There are not many empirical studies that apply the Fuzzy Hybrid Approach to Social Science, although Ragin (2000) recommended the application of Fuzzy Theory as strengthening the relationships among theory and data analysis in sociology and political science.

4.1 The fuzzy topsis hybrid method

This method consists of 6-consecutive stages, which are summarized in Fig. 1 (Cantillo et al. 2020). In our study, FST is applied to handle the vagueness of the information provided by answers given to the questionnaire. We first convert the semantic ordinal scales into Triangular Fuzzy Numbers (TFNs). Salih et al. (2019) reviewed the studies that use the keywords 'TOPSIS' or 'technique for order preference by similarity ideal solution' and 'development' and 'fuzzy', and the authors concluded that TFNs are still the most common fuzzy sets used by researchers when they deal with uncertainty and vague information.

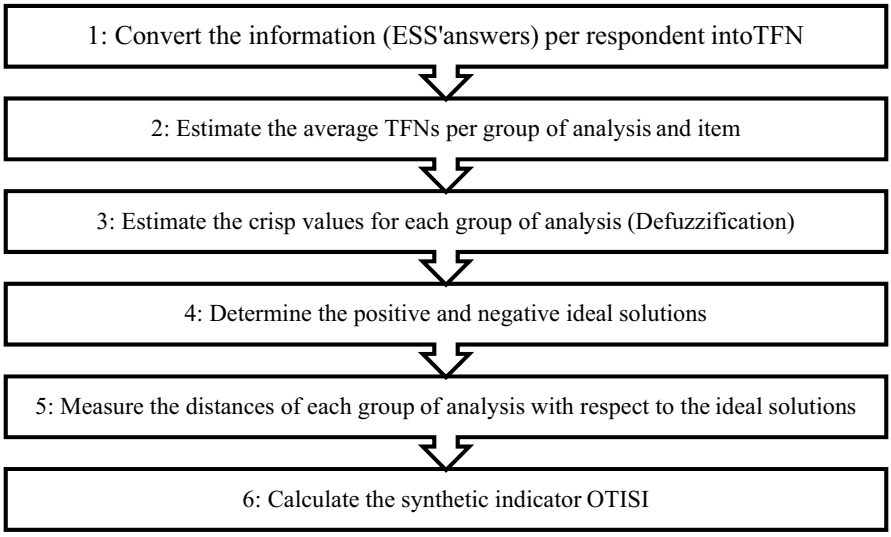

Fig. 1 Synthetic diagram of the methodology FHA

Triangular fuzzy numbers are characterized by a triplet (a1, a2, a3) of real numbers. Thus, we assign each point of the semantic scale a TFN. A TFN $\tilde{A}$ is usually parametrized as follows:

$$\mu_A(x) = \begin{cases} \frac{x-a_1}{a_2-a_1}, & a_1 \le x \le a_2 \\ \frac{x-a_3}{a_2-a_3}, & a_2 \le x \le a_3 \\ 0, & otherwise \end{cases} \tag{1}$$

Table 4 presents the transformation of the semantic ordinal scales provided by the respondents into TFNs characterized because the universe of discourse is within the interval [0, 100]. The interval of the discourse is chosen for clarity without loss of generalization. In each of the scales, it can be seen that the information provided is vague as all the consecutive ordinal semantic points are represented by 3-uples that intersect in some interval. For example, the interval (30, 50) is in the intersection of the first two points (none and a few) for the items C1–C3. The relative strength of each interval can be calculated according to (1).

Fuzzy Set Logic Algebra facilitates the aggregation of TFNs. Thus, it is straightforward to calculate whether a particular age or religious group (or any group obtained from the set of the eleven covariates under analysis) is more open towards immigrants than others. The algebra of TFNs is applied here to calculate the average fuzzy number of n TFNs $A_i = \left(a_1^{(i)}, a_2^{(i)}, a_3^{(i)}\right)(i = 1, 2, \ldots, n)$ as follows:

$$\tilde{A} = (a_1, a_2, a_3) = \left(\frac{1}{n}\right) \otimes \left(\widetilde{A_1} \oplus \widetilde{A_2} \oplus \cdots \oplus \widetilde{A_n}\right) = \left(\frac{\sum_{i=1}^{n} a_1^{(i)}}{n}, \frac{\sum_{i=1}^{n} a_2^{(i)}}{n}, \frac{\sum_{i=1}^{n} a_3^{(i)}}{n}\right) \tag{2}$$

where $\otimes$ stands for the external multiplication of a scalar and a TFN, and $\oplus$ is the internal addition of TFNs (Buckley 1985). The properties of the algebra guarantee that the average of TFNs is also a TFN.

Table 4 Triangular fuzzy numbers

Scale	Fuzzy number[a]	Fuzzy number[b]
1	(0, 0, 50)	(0, 0, 10)
2	(30, 50, 70)	(0, 10, 20)
3	(50, 70, 90)	(10, 20, 30)
4	(70, 100, 100)	(20, 30, 40)
5		(30, 40, 50)
6		(40, 50, 60)
7		(50, 60, 70)
8		(60, 70, 80)
9		(70, 80, 90)
10		(80, 90, 100)
11		(90, 100, 100)

Source Own elaboration

Default values of the scale

[a]Indicators C1–C3

[b]Indicators C4–C6

In the study, we analyse 71 different socio-demographic groups obtained from the eleven used covariates, and the average TFN can be obtained for each of these segments of interest. Thus, a matrix (6, 71) of TFNs is obtained by applying Eq. (2). This matrix is known as the TFN information matrix, and it contains a lot of information that is difficult to analyse. For this reason, a defuzzification of the matrix is carried out to synthesize the information (Kumar 2019). Thus, we transform the fuzzy information matrix into a plausible real number or crisp value information matrix as uncertainty and information vagueness have been adequately handled.

Kaufmann and Gupta (1988) provides a defuzzification method by calculating the weighted average of the 3-uple that represents the respective TFN of the fuzzy information matrix. Thus, we give more importance to the value that, according to fuzzy logic, contains more truth. Therefore, the defuzzified value is obtained as follow:

$$v\tilde{A} = \frac{(a_1 + 2a_2 + a_3)}{4} \tag{3}$$

Kaufmann and Gupta (1988) named this approach the centroid method. It turns out to be a simple method, robust and with good properties (Martín et al. 2016, 2019).

4.2 TOPSIS' steps to obtain OTISI

TOPSIS was first proposed by Hwang and Yoon (1981), and, in the study, it is applied to the crisp information matrix to calculate the synthetic indicator of openness towards immigrants.

The three first steps have already been explained in the previous section. So, now we are going to further explain how the ideal solutions are obtained. As explained above, we have now a crisp information matrix V with dimensions (6, 71) that contains the defuzzified value for each item and population group. Thus, it is now possible to determine the positive and negative-ideal solutions that are obtained after the aggregation stage (step 3, Fig. 1). As all the items were recoded to associate high values with more openness towards immigrants, TOPSIS is applied considering all the items as benefit values (Behzadian et al. 2012). Thus, the positive ideal solution is obtained by the maximum figures observed in the matrix. Following the same logic, the negative ideal solution is characterized by the minimum figures. Mathematically, the positive and negative ideal solutions are measured, respectively, as follows:

$$A_i^+ = \left\{ \left(max V_{ij} \right), \quad j = 1, 2, \ldots, 71 \right\}, \quad i = 1, 2, \ldots, 6 \tag{4}$$

$$A_i^- = \left\{ \left(min V_{ij} \right), \quad j = 1, 2, \ldots, 71 \right\}, \quad i = 1, 2, \ldots, 6 \tag{5}$$

Once the positive and negative ideal solutions are obtained, the TOPSIS approach measures the Euclidean distances between each group observation and the ideal solutions. The Euclidean distances, S_j^+ and S_j^-, and $OTISI_j$ are calculated as follows:

$$S_j^+ = \sqrt{\sum_{i=1}^{6} \left(A_i^+ - V_{ij} \right)^2} \quad and \quad S_j^- = \sqrt{\sum_{i=1}^{6} \left(A_i^- - V_{ij} \right)^2} \tag{6}$$

$$OTISI_j = \frac{S_j^-}{S_j^+ + S_j^-} \rightarrow [0, 1] \tag{7}$$

A particular group observation perceives immigrants more positively when OTISI is closer to one. Therefore, we rank our segments using the OTISI values of all observations, in descending order, to find which population group is more open to immigrants. The OTISI's logic is clear because the indicator is higher for those segments closest to the positive ideal solution and further away from the negative ideal solution (Martín et al. 2016, 2019).

5 Results and discussions

Here, we present and discuss the results obtained. Table 5 shows the TFNs and the defuzzified values that represent the total sample analysed in the study. TFN contains a lot of information that cannot be easily interpreted, and usually, this is a source of tension and stress for readers unfamiliar with fuzzy set theory. Looking at the respective TFNs values, it can be seen that all TFNs overlap. This is not a surprise at all as it shows the essence of fuzzy set theory when information is extracted from the uncertainty derived from semantic or Likert-type scales. For this reason, we use crisp clear values to synthesize the information. The crisp column shows that respondents show a more positive ATI towards immigrants of the same race or ethnic group as the majority and are less open about religious beliefs and practices. The results concur with those obtained by Yavcan (2013) who found that citizens perceive different threats based on immigrants' culture.

The ideal positive and negative solutions have been calculated according to Eqs. (4) and (5). Table 6 shows the ideal solutions and the representative segment of the positive ideal solution (PIS) and the negative ideal solution (NIS). The PIS is characterized by Germany, Sweden, Portugal, and Finland. Similarly, the negative ideal solution is represented by Slovakia, Hungary, and the Czech Republic. Our results complement other analyses, for example, Bail (2008). New immigration destination countries, such as the countries of Eastern Europe, appear to be those which base attitudes towards immigrants on racial and religious diversity. Thus, according to Allport et al. (1954) racial and religious stereotypes could limit positive contact between culturally diverse groups. On the other hand, countries that admit immigrants since the post-First World War, North EU countries, are more tolerant than other countries which have restricted more tightly their borders to immigrants. Hence, anti-racist speeches and integration policies eradicated symbolic racial and religious prejudices and facilitated positive contact between nationals and non-European immigrants (Bail 2008; Heath and Richards 2020).

Table 5 TFNs and crisp clarified values for the total sample

Observation	TFN	Crisp value
Total (C1)	(46.57, 67.40, 84.92)	66.57
Total (C2)	(38.92, 57.18, 79.05)	58.08
Total (C3)	(37.42, 55.12, 77.87)	56.38
Total (C4)	(42.07, 51.38, 60.93)	51.44
Total (C5)	(40.43, 49.82, 59.42)	49.87
Total (C6)	(44.25, 53.63, 62.97)	53.62

Table 6 Positive and negative ideal solutions

Attribute	Apos	Group	Aneg	Group	% var
C1. Allow many/few immigrants of same race/ethnic group as majority	77.58	Germany	51.46	Slovakia	50.8%
C2. Allow many/few immigrants of different race/ethnic group as majority	74.00	Sweden	37.69	Hungary	96.3%
C3. Allow many/few immigrants of poorer countries outside Europe	71.98	Sweden	29.54	Hungary	143.7%
C4. Immigration is bad or good for country's economy	62.88	Portugal	35.93	Hungary	75.0%
C5. Country is a worse or better place to live by immigrants	63.68	Sweden	36.80	Czechia	73.0%
C6. Country's religious beliefs and practices are undermined or enriched by immigrants	69.63	Finland	36.71	Czechia	89.7%

Source Own elaboration

Openness towards immigrants' scale

Positive and negative ideal solutions provided group profiles for the most and least openness towards immigrants, respectively. Thus, we calculated the Euclidean distances between each population group of analysis and the ideal solution. Through (7), the Openness Towards Immigrant Synthetic Indicator (OTISI) for all the 71 population groups is obtained (Table 7). We obtain OTISI to measure openness towards the immigrants for each population group obtained from the categories of the 11 covariates used in the study (country, political orientation, age, religion, economic situation, gender, birthplace, employment, education, universalism, and conformity).

Our results show that: (1) Eastern countries are less open than Western and Nordic countries; (2) left-wing citizens are more open than right-wing citizens; (3) younger citizens are more open than older citizens; (4) Islamic and other eastern religions seem to make practitioners more open than being agnostic or Christians; (5) a good economic situation seems to increase the openness towards immigrants; (6) men are slightly more open than women; (7) foreign-born citizens are more open than native-born citizens; (8) retired and unemployed citizens are less open than workers and students; (9) universalism tend to increase the openness towards immigrants; (10) traditionalism tend to decrease the openness towards immigrants; and (11) high educated citizens are more open than low educated people.

The countries can be split into three main macro-areas: those that showed negative attitudes towards immigrants (Eastern European countries), those that preferred selective immigration policies (Western European countries), and those showing more positive attitudes towards immigrants (Northern European countries). Although, Austria and Italy seem to be more similar to the Eastern countries than to Western European countries. Results are concordant with other previous studies (Bail 2008; Chylíková 2016; Davidov et al 2018; Heath and Richards 2020; Martín and Indelicato 2021).

Our results agree with Löw et al. (2022) who found that the cultural model of Eastern European countries is fundamentally different from that of Western countries. In this case, anti-immigrant sentiments are rooted in the fear of losing the traditional culture of the community. On the other hand, Western countries have experienced and overcome several ethnic and religious pressures. Despite that, they addressed the issue of migratory crisis, implementing integration policies. And finally, Northern European countries resulted to be more open towards immigrants because they have probably been more exposed to the phenomenon of immigration than other countries in Europe. The immigrants helped the countries of Northern Europe to develop their economies. Therefore, the citizens perceive immigrants as a resource rather than a threat, in that immigrants have contributed to the development of this area in the fields of research, arts, and culture.

Similarly, Brenner and Fertig (2006) and Alonso and Fonseca (2012) contended also that political orientation was a crucial factor in the analysis of attitudes towards immigrants. The positive relationship between attitudes towards immigrants and left-wing political orientation is explained by the fact that left-wing citizens perceive immigrants as a resource that can be used to solve labour market problems and fill gaps in sectors health care and pensions (Ruhs 2012). Right-wing citizens, in contrast, tend to perceive immigrants as a threat to the social system and to their jobs, which supports the ethnocentrism of right-wing voters. Therefore, the association between right-wing citizens and negative attitudes towards immigrants is explained by the fact that right-wing citizens tend to have more ethnocentric views and perceive their country as a culturally homogeneous society. Since they perceive their society as homogenous, they are more likely to reject immigrants who are members of a minority group (Alonso and Fonseca 2012).

Table 7 Openness towards immigrants' synthetic indicator

Group	Covariate	OTISI
Sample total		0.568
Hungary	Country	0.077
Czechia		0.134
Slovakia		0.161
Bulgaria		0.210
Cyprus		0.310
Serbia		0.415
Montenegro		0.435
Austria		0.463
Estonia		0.470
Italy		0.470
Slovenia		0.499
Poland		0.521
Lithuania		0.544
Latvia		0.553
Croatia		0.604
France		0.642
Finland		0.719
Belgium		0.727
Netherlands		0.735
United Kingdom		0.745
Ireland		0.795
Germany		0.804
Spain		0.805
Switzerland		0.806
Portugal		0.819
Norway		0.882
Sweden		0.934
Right	Political orientation	0.352
Centre-right		0.517
Centre		0.591
Left		0.686
Centre-left		0.765
76 years or over	Age	0.438
66–75 years		0.495
56–65 years		0.551
46–55 years		0.580
36–45 years		0.642
26–35 years		0.681
25 years or under		0.748
Christian	Religion	0.512
Agnostic		0.623
Jewish		0.712
Islamic		0.801

Table 7 (continued)

Group	Covariate	OTISI
Other		0.828
Very Difficult	Economic situation	0.281
Finding it difficult		0.378
Good		0.542
Comfortably		0.775
Female	Gender	0.564
Male		0.572
Born in the country	Birthplace	0.540
Foreign-born		0.814
Retired	Employment	0.441
Unemployed		0.514
Other		0.546
Paid work		0.613
Student		0.817
Not like me at all (U)	Universalism	0.387
Like me (U)		0.581
Very much like me (U)		0.751
Very much like me (C/T)	Conformity/traditions	0.487
Like me (C/T)		0.556
Not like me at all (C/T)		0.684
Lower tier upper secondary	Education	0.420
Less than lower secondary		0.439
Lower secondary		0.477
Upper tier upper secondary		0.489
Advanced vocational, sub-degree		0.648
Lower tertiary education, BA level		0.784
Higher tertiary education, ≥ MA level		0.830

Our results suggest that education is also an important factor that influences attitudes towards immigrants. Similarly to McAllister (2018), we found that people with low levels of education are less probably to be tolerant towards immigrants than high-educated citizens. Results show that the relationship between educational level and negative attitudes towards immigrants is explained by the fact that people with higher levels of education tend to be more critical of the economic and political systems that govern their countries. This critical attitude, in turn, leads them to question the government's policy towards immigrants (Brenner and Fertig 2006; Fussell 2014).

Several studies have found similar results regarding the economic situation (Celi et al., 2005; Ceobanu and Escandell 2010). Unemployment can be considered as a factor to develop negative attitudes towards immigrants which are directly derived from the perception of competition in the labour market. Thus, those who are more economically vulnerable tend to be more critical towards immigrants because they can perceive immigrants as a threat to their livelihood.

And finally, regarding religion and birthplace, our results are also similar to those obtained by other researchers (Coenders et al. 2009; Kuntz et al. 2017; Raijman et al.

2008). Muslims seem to be more open to immigrants than Christians, and this can be reasonably explained by the fact that some of them are probably immigrants. For the same reason, foreigners appear to show more positive attitudes towards immigrants than natives.

6 Conclusions

The paper introduces a method based on FHA to provide a synthetic indicator that measures the citizens' openness towards immigration. This topic is of great interest to academics, policymakers, and the general public. It is important to understand the immigration phenomenon for the development of suitable social and political immigration policies at the country level.

Many authors have studied ATI using mainly CFA and SEM approaches (Meuleman and Billiet 2012; Semyonov et al. 2006; Sønderskov and Thomsen 2015; Thomsen and Rafiqi 2018). In the study, the authors propose to use a novel approach in the field based on fuzzy set theory. Thus, the new method provides an openness towards immigrants' synthetic indicator (OTISI) that can be used to rank the openness for 71 population groups obtained from the categories of eleven covariates namely country of residence, political orientation, age, religion, economic situation, gender, born in the country, unemployed, universalism, traditionalism, and education. We used the European Social Survey (2018) round 9 datasets in 27 countries.

The results show that there are differences in attitudes towards immigrants. Countries can be split into three main macro-areas: Eastern European countries that showed the most negative attitudes; Western European countries that showed intermediate openness based on selective immigration policies; and Northern European countries that showed the most positive attitudes. Although Italy is one of the members that signed the treaty of Rome, it obtains OTISI values similar to the first macro area, with lower figures than other countries, such as Slovenia, Poland, Lithuania, and Latvia. Internal socio-demographic and political factors can be the cause of such a result (Di Matteo and Mariotti 2021).

According to the OTISI ranking, we can summarize the profile of the groups that showed a more positive attitude towards immigrants as young students and left-wing voters, North European citizens, foreigners, highly educated, practising Muslim or other religion, having a good economic position, universalist and non-traditionalist, and being a student or an employee.

Previous studies have also analysed the main determinants that explain attitudes towards immigrants. The current study complements them using a novel Fuzzy Hybrid Approach in the field. Di Nardo and Simone (2019) contended that standard statistical models do not handle properly the inherent vagueness information provided by semantic ordinal scales, and this issue is particularly relevant in many social science questionnaires. The Fuzzy Hybrid Approach provides a mathematical method that analyses these shortcomings with precision, not via a definite cut-off, but by defining a degree of membership among individuals. Thus, we consider that FHA is an appropriate approach that could be very fruitful in future empirical analysis in the field. The paper reproduces the already known results from other studies reinforcing the good applicability of the method in the field of social science.

Like any other study, there are also some limitations. First, the study is only static, and it is based on round 9 of the ESS. It would be interesting to study the dynamic evolution of OTISI using some other rounds of the survey. Second, the dataset is only based on the ESS.

Future research can consider other databases to analyse the results' robustness in the use of different sources of information. Third, another venue for future research is to test whether the method can also be used to analyse other topics, such as national identity or patriotism, to see whether the method produce again robust results.

Annex 1

This section details the recoding process made for the original ESS dataset. For example, the country, which is a two-character code in ESS, has been recoded in the study as: Austria (1); Belgium (2); Bulgaria (3); Switzerland (4); Cyprus (5); Czechia (6); Germany (7); Denmark (8); Estonia (9); Spain (10); Finland (11); France (12); United Kingdom (13); Croatia (14); Ireland (15); Iceland (16); Italy (17); Lithuania (18); Latvia (19); Montenegro (20); Netherlands (21); Norway (22); Poland (23); Portugal (24); Serbia (25); Sweden (26); Slovenia (27); Slovakia (28). The political orientation variable (11 points) was recoded into five categories according to the following procedure: Left (0–1); Centre-Left (2–3); Centre (4–6); Centre-Right (7–8); and Right (9–10). The age variable was recoded into seven different categories according to: 25 years or under (1); 26–35 years (2); 36–45 years (3); 46–55 years (4); 56–65 years (5); 66–75 years (6); and 76 years or over (7). The religion was recoded into five different categories according to: Christian (1–4 in the ESS were recoded as (1)), Jewish, 5 in the ESS, was recoded as (2); Islamic, 6 in the ESS, was recoded as (3); Other Eastern and non-Christian religions, 7–8 in ESS, were recoded as (4); and finally we recode those who did not answer the religion question for not considering themselves as belonging to any particular religion as agnostic (5). The covariate income (hincfel) measures the feeling about the current household's income and the dataset is obtained directly from the codes given by ESS as: living comfortably on present income (1); coping on present income (2); finding it difficult on present income (3); finding it very difficult on present income (4). Gender (gndr) is coded as: Male (1) and Female (2). Citizenship (brncntr) is coded as: Born in the country (1) and Foreign-born (2). Unemployed (mnactic) is recoded as follows: paid work (1), student (2), unemployed (3–4 in ESS), retired (5), other (6–8 in ESS).

We explain separately the two covariates that represent human values such as universalism and conformity/tradition as they are transformed from the raw data obtained by ESS on six items of the Portrait Value Questionnaire (PVQ) 21, which is a modification of the PVQ-40 (Schwartz 2007). The 21 items are used to describe the human values of the citizens. In this regard, we follow Davidov et al. (2018) to create the two covariates using two items of universalism (ipeqopt and ipudrst) and four items of conformity/traditions (ipfrule, ipmodst, ipbhprp and imptrad). The answer format for all the items of the PVQ-21 is based on a semantic six-point scale as follows (Not like me at all (1); Not like me (2); A little like me (3); Somewhat like me (4); Like me (5); Very much like me (6)). We highlight here that the format has been reversed from the original raw dataset in ESS. The two items for universalism are based on the answers given to the following questions: it is important that people in the world are treated equally and have equal opportunities in life; and it is important to listen to people who are different from us even if we disagree with them, we still want to understand them. Meanwhile, the four items included in the conformity/traditions covariate are: it is important to do what is told and follow rules at all times, even when no one is watching; it is important to be humble and modest, and not draw attention; it is important to behave properly and avoid doing things people would say are wrong; it

is important to follow traditions and customs handed down by religion or family. Then, we calculate the average values for the two covariates included, and, finally, universalism and conformity/traditions are coded as follows: (1) when the average value is lower than the percentile 33; (2) when the average value is equal or greater than percentile 33 and equal or lower than percentile 66; and (3) when the average value is greater than percentile 66. Other more extreme percentiles could have been used to determine the main effects of the covariates but we preferred to be conservative in this respect.

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