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Measuring Tolerant Behavior

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Abstract: This paper addresses the issue of measuring tolerance, viewed as a multifaceted phenomenon involving several different social domains. We develop a multidimensional index for Likert-scale data, characterized by the following features: *(i)* it reflects the individual's intensity of tolerant attitudes towards each social domain; *(ii)* the index can be broken down by dimension in order to determine the contribution of each dimension to overall tolerance; *(iii)* the index combines the different dimensions of tolerance using a weighted scheme that reflects the importance of each dimension in determining the overall level of tolerance. To show how this new measure of tolerance works in practice, we carry out a case study using an Italian recent survey asking the opinion of university students about different subjects, such as interreligious dialog, women/religion relationship, religion/death relationship, homosexuality, and multicultural society.

Keywords: tolerance, economic behavior, social interactions, multidimensional index
JEL Classification: A13, C43

1 Introduction

In recent years, the topic of tolerance has been receiving increased interest in the economic literature. A number of studies have found a positive relationship between tolerance and several economic outcomes, including foreign direct investment, sovereign debt ratings, and GDP growth (Berggren and Elinder 2012; Noland 2005). Moreover, tolerant societies act as a magnet for people with talent and for people endowed with high levels of human capital. The concentration of such

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people contributes to the rise of entrepreunership, innovation and local development (Florida 2003; Florida and Gates 2003; Florida et al. 2008). In several papers, surveyed in Section 2, tolerance is seen as openness, inclusiveness, and diversity to all ethnicities, races and walks of life (Florida 2003, p. 10). The analysis is usually based on surveys with questions such as "*Would you like to have homosexuals as your neighbors?*" or "*Would you like to have people of a different race as your neighbors?*"[1] They are simple yes/no questions, formally known as polar questions, which give a clear-cut understanding of people attitudes. The fraction of respondents giving a positive answer is the measure of tolerance (see, for example, Berggren and Elinder 2012). In the present paper, we aim at contributing to this flourishing research area by adopting a wider perspective and looking at tolerance as a concept involving several different social domains, so that attitudes towards homosexuals and foreign-born people are only a partial aspect of this phenomenon.[2] We develop an index of tolerance able to summarize into a single value individuals' attitudes towards different social domains, such as homosexuality, multicultural society, women's emancipation, abortion and euthanasia. The index, constructed for Likert-scale data, is obtained via a geometric aggregation of tolerance dimensions, differently from other studies that use linear indices.

There are various reasons for choosing our index to measure tolerance. In the first place, the index incorporates the individuals' scores of the Likert scale, reflecting the intensity of tolerant attitudes. Second, the index can be broken down by dimension. This allows to determine the contribution of each dimension to overall tolerance. Third, the index combines the different dimensions of tolerance using a weighted scheme that reflects the importance of each dimension in determining the overall level of tolerance.

To show how this measure of tolerance works in practice, we carry out a case study using an Italian survey asking the opinion of university students about different subjects, such as interreligious dialog, women/religion relationship, religion/death relationship, multicultural society, and homosexuality.[3]

The rest of the paper is organised as follows. Section 2 reviews the economic literature on tolerance. Section 3 presents the index of tolerance. Section 4 presents

1 Both questions are from the World-Values-Survey-Association (2015).

2 As we will discuss deeper in Section 2, most papers about tolerance mainly focus on homosexuality and ethnic minorities. However, few studies also consider other dimensions such as tolerant attitudes towards women (see, for example, Gani 2015).

3 The survey is part of an ongoing interdisciplinary research project carried out within the framework of the *Framework Convention (FC) Gender and Religions*, that has been developed to enhance knowledge sharing and research collaboration on the complex relationship between women, men and interreligious dialog. For further details, see Decataldo et al. (2019).

the empirical application. The last section concludes the paper with suggestions for further developments.

2 Related Economic Literature

In early studies, tolerance has not been conceptualized in a clear different way from diversity (Qian 2013; Reese and Sands 2008). "*Tolerance, openess and diversity are generally conflated or interchangeably used [in Florida's work]*" (Qian 2013, p. 2718). Consistently with this conceptualization of tolerance, Florida (2002) uses different measures of population diversity to represent tolerance (Reese and Sands 2008).

Qian (2013) argues that tolerance should be differentiated from diversity when we study the role of social factors on local economic development since the two phenomena generate different effects in the economic system. The author reports the definition given by the Merriamâ€ Webster dictionary,[4] and he identifies at least two main differences between the two concepts. First, the definition of tolerance relies on the existence of an individual standard. The wider the deviation from the standard, the more tolerant the individual is. Second, tolerance and diversity are not necessarily related. Quoting Ottaviano and Peri (2006), Qian (2013) observes that diversity requires an even distribution of individuals across a large number of groups. Tolerance, in contrast, is high in society when the two most different groups are integrated. In Qian's empirical analysis carried out on US metropolitan areas, tolerance is measured by the Tolerance Index developed by Florida et al. (2008), and corresponding to the average of the Gay Index and the Bohemian Index[5]; diversity is measured by the complement to one of the Herfindahl-Hirschman index. The results show that tolerance has an indirect effect on both innovation and entrepreunership via talent attraction. Diversity has no significant association with innovation, while it exhibits a direct positive association with entrepreunership also when the latter is considered in the high technology context.

Other recent studies look at the relationship between tolerance and innovation. For example, Audretsch et al. (2018) analyze the role of social trust and

4 Tolerance is defined as *"sympathy or indulgence for beliefs or practices differing from or conflicting with one's own" or "the allowable deviation from a standard."* Diversity is defined as *"the condition of having or being composed of differing elements", especially "the inclusion of different types of people (as people of different races or cultures) in a group or organization"* (Qian 2013, p. 2722).

5 The Gay Index is the share of the gay and lesbian population; the Bohemian Index is the share of the artistic population.

institutional context in affecting the impact of tolerance on innovation. In their paper, tolerance is measured by the level of openness to gays and lesbians. The analysis is carried out using a large data set including 138 countries, 51 US states and 31 Chinese regions. The results confirm the positive effect of tolerance on innovation. Social trust strengthens the tolerance-innovation relationship even if the effect of social trust is displaced when controlling for the role of formal institutions and a strong rule of law. Boschma and Fritsch (2009) analyze for seven European countries the economic effect of the regional distribution of the *creative class*, term coined by Florida (2002) to indicate workers strongly involved in creative activities. They show that a regional climate of tolerance and openness act as a magnet for talented and creative people. Tolerance and openness are measured by two indicators: the first is the Bohemian Index defined by Florida (2003) as the share of the regional population in bohemian occupations; the second indicator is the share of foreign-born people (even if the authors acknowledge that a more diverse population is not necessarily more tolerant). The creative class, in turn, contributes to regional development via different channels depending on country.

Several papers analyze the role of tolerance in the economic system without making a clear distinction between tolerance and diversity. Among them, Noland (2005) considers two indicators of tolerance: the first is the share of population stating that local culture should not be protected from foreign influence; the second indicator is the share of population according to which homosexuality should be tolerated. The analysis carried out on 44 countries shows that accepting homosexuality and opening local culture to foreign influence contribute to attract more foreign direct investment, to obtain better debt ratings, and to exhibit more local entrepreneurship. Florida in his works and those with coauthors (Florida 2003; Florida and Gates 2003; Florida et al. 2008) emphasizes all the positive effects of tolerance on the economic development at the local level (city or region). Using almost exclusively data from American cities, he shows that cities or regions with low entry barriers to newcomers are characterized by higher concentrations of talents, higher rates of innovation, and higher rates of regional development. Berggren and Elinder (2012) adopt Florida's definition of tolerance reported in the Introduction to analyze how tolerance affects economic growth in 54 countries. Tolerance is measured by two variables: the share of population that does not dislike to have homosexuals as neighbors, and the share of population that does not dislike to have people of a different race as neighbors. The results show a relatively robust negative effect of tolerance towards homosexuals on growth, while the effect of tolerance towards people of other races is not statistically significant. Three possible mechanisms are put forward to explain the negative relationship: first, tolerance towards homosexuals reduces the productivity of intolerant but productive and innovative people; second, tolerance reduces the

average productivity of homosexuals by affecting choices of education and occupation, and by reducing the felt need to work hard to prove one's worth; third, homosexuals have, on average, less strict and less future-oriented values, which disseminate easier with increased tolerance (Berggren and Elinder 2012, p. 285). Schmutzler and Lorenz (2017) adopt similar measures as those developed by Florida to examine the effect of tolerance on the innovation performance of firms in seven Latin American countries. Their analysis shows that differences in the level of tolerance matter for innovation performance. Moreover, it turns out that tolerance has a positive effect on the probability that firms on average will implement product innovation.

Table C in Appendix summarizes the empirical studies mentioned above with the variables and measures used for tolerance. As one can see from this table, most of the variables are about homosexuality, people of different race, foreign-born population, immigrants. The measures are either shares of people with a feature over total population or an average of different shares. The only exception is Schmutzler and Lorenz (2017). In Section 3, we introduce our index of tolerance and discuss its difference with linear measures, such as the average of two or more shares.

Turning to theoretical studies, Cerqueti et al. (2013) define tolerance as a generic ability to accept diversity and develop a mathematical model to analyze the dynamics of tolerance among heterogeneous economic agents. They show that a fully tolerant society assures prosperity and that cultural integration should precede economic integration. Also Shi and Pan (2017) and Shi and Peng (2014) use an evolutionary game model of social tolerance similar to that used by Cerqueti et al. (2013) to study the dynamics of tolerance in a society with multiple groups (the former), and in a society with local social cost functions (the latter).

The tolerant behavior has been described by Corneo and Jeanne (2009) who develop a model based on endogeneous preferences (see, among others, Adriani et al. 2018; Adriani and Sonderegger 2009; Bisin and Verdier 2001). They develop a two-generation model to identify the circumstances under which parents have an incentive to transmit a value system that attaches relatively equal worth to different traits and lifestyles. Tolerance is considered as a proxy of the value system endorsed by people. The model shows that tolerance is spontaneously transmitted if the ensuing psychic cost is outweighted by the private benefits conferred by tolerance.

In this paper, we adopt the definition of tolerance provided by Berggren and Elinder (2012), according to which "a tolerant person is assumed to accept the presence and the participation of all kinds of people in society, regardless of what he thinks or feels about them" (Berggren and Elinder 2012, p. 284). This definition implicitly implies that a large variety of social domains can be analyzed to assess the overall level of tolerance in society. In the next section we address the problem of measuring tolerance.

3 Tolerance Index

In this section, we develop a statistical measure of tolerance for Likert scale data. Likert items are used to measure respondents' attitudes to a particular question or statement. For example, survey questions, used in our case study and devoted to detect individuals' attitudes towards some topics including homosexuality, immigrants and women's emancipation, have been measured by a five-point Likert scale.

We introduce two main assumptions to use the survey's questions in order to elicit individual preferences.[6] First, we assume that responses provided by different individuals are interpersonally comparable at an ordinal level. This implies that individuals who select the same point on the Likert scale have a similar attitude. Second, we assume that there is a correspondence between what we measure and the abstract concept we are interested in. In other terms, it is reasonable to assume a strong positive relationship between high rate (low rate) assigned to survey's questions and individual's positive (negative) attitudes towards a topic.

The setup considers a population of n individuals indexed by $i = 1, \ldots, n$. Tolerance is assessed through a questionnaire composed of M items. Let $it_m(i)$ denote the answer to a generic item it_m measured by a J-point Likert scale. The Likert-scale has several formulations. In our case we consider a rating scale $j = 1, \ldots, J$, where J is an odd number of response options.[7] Moreover, the semantic differential version (Osgood 1964) of the Likert scale is considered in order to be symmetric with respect to zero and to range between $\left(-\frac{J-1}{2}, +\frac{J-1}{2}\right)$. In this way, we obtain a scale ranging from negative to positive values giving, at the same time, the direction and the intensity of respondents' attitudes. The zero value reflects the neutral position of the individual towards a topic.

Let $\boldsymbol{it}_m$ a column vector $(n \times 1)$ composed of the individual's score in rating item m. Let $\boldsymbol{X} = [\boldsymbol{it}_1, \boldsymbol{it}_2, \ldots \boldsymbol{it}_M]$ a $(n \times M)$ matrix, representing the distribution of the M items across n individuals.

The matrix $\boldsymbol{X}$ is decomposed in $K < M$ sub-matrices $\boldsymbol{X}_k\,(k = 1, ..K)$, where K is the number of tolerance dimensions. Formally, the matrix $\boldsymbol{X} = [\boldsymbol{X}_{1(n\times p_1)}, \boldsymbol{X}_{2(n\times p_2)}, \ldots \boldsymbol{X}_{K(n\times p_K)}]$, with $\sum_{k=1}^{K} p_k = M$. Notice that the dimension of sub-matrices, in particular the number of columns, may not be the same for all of them. This is because a survey may have a different number of questions related to each topic.

The idea behind our index is sketched in Figure 1.

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6 These two hypothesis were originally introduced by van Praag et al. (2003) in a different theoretical framework aiming to explain the concept of subjective well-being.

7 The case wih J even is discussed in the Appendix.

The index is obtained following a two-step procedure: in the first step the K sub-matrices are reduced to K column vectors $(n \times 1)$ denoted by $\boldsymbol{F}_k$. The elements of $\boldsymbol{F}_k$ are the rows' median of sub-matrix $\boldsymbol{X}_k$. In formal terms:

$$F_k(i) = Me(X_k(i)), \quad i = 1, \ldots, n \tag{1}$$

The median has been preferred to other measures of central tendency (as, for example, the arithmetic mean) in order to preserve the original Likert-scale graduation.[8]

In the second step, the $\boldsymbol{F}_k$ vectors are reduced into a scalar value (denoted by T in Figure 1), which corresponds to the assessment of tolerance for the observed population.

Formally, the elements in $F_k(i)$ are summed up as follows: $\mathcal{F}_k = \left|\sum_{i=1}^{n} F_k(i)\right|$. We obtain K numerical values that are, in turn, aggregated using the following weighting formula:

$$T = (\mathcal{F}_1 + 1)^{(\theta_1)\beta_1} \cdot (\mathcal{F}_2 + 1)^{(\theta_2)\beta_2} \cdot \ \ldots \ (\mathcal{F}_K + 1)^{(\theta_K)\beta_K} \tag{2}$$

where

– $\beta_k \in [0, 1]$ is the complement to one of L_k, which denotes the normalized Leti's

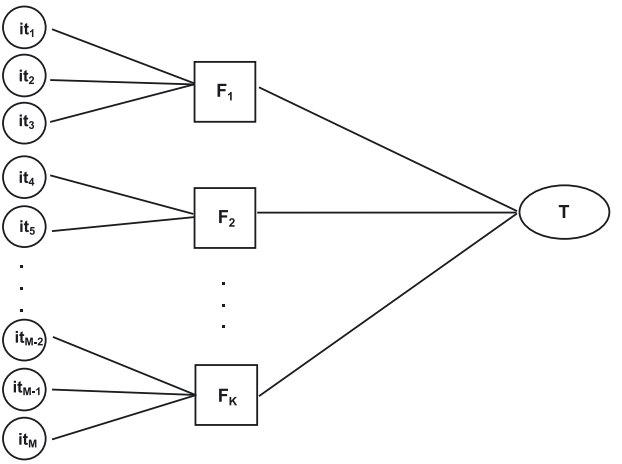

Figure 1: Tolerance Index: the basic idea.

8 If $X_k(i)$ is composed of an even number of items, we could have a pair of middle Likert scale values. The median is either the left middle number or the right middle number. The choice can be made randomly (Piccolo 1998, p. 106).

heterogeneity index (Leti 1965) computed on the relative frequency distribution (f) of $\boldsymbol{F}_k$:

$$\beta_k = 1 - \frac{L_k - 1}{J - 1} \tag{3}$$

$$L_k = \prod_{j=1}^{J} \left(f_{jk}\right)^{-f_{jk}} \tag{4}$$

– θ_k is an indicator function:

$$\theta_k = \begin{cases} -1 \text{ if } \sum_{i=1}^{n} F_k(i) < 0 \\ +1 \text{ if } \sum_{i=1}^{n} F_k(i) \geq 0 \end{cases} \tag{5}$$

The composite index T (Eq. (2)) is obtained via a geometric aggregation of the different tolerance dimensions.This aggregation method has been preferred to the linear method, which is perhaps the most commonly used in composite indicators (see Greco et al. 2018, and references therein). However, the linear method is based on the following two strong assumptions: first, the independence among dimensions, i. e. any tolerance dimension is independent on the other tolerance dimensions (Fusco 2015; Munda and Nardo 2009); second, a constant compensability between dimensions (Decancq and Lugo 2013). Thus a higher score in one of the tolerance dimensions compensates for the loss in another dimension. The geometric aggregation assumes only some degree of compensability (OECD 2008, p. 28). Hence, a lower score in a given dimension is not able to compensate fully in other dimensions (Greco et al. 2018). We further discuss the two aggregation methods in Sections 3.1 and 4.

Without loss of generality, we can rewrite the T index in logarithmic form as follows:

$$\log(T) = (\theta_1)\beta_1 \log(\mathcal{F}_1 + 1) + (\theta_2)\beta_2 \log(\mathcal{F}_2 + 1) + \ldots + (\theta_K)\beta_K \log(\mathcal{F}_K + 1) \tag{6}$$

On the right-side of Eq. (6), the parameter β_k measures the degree of homogeneity of the relative frequency distribution f_k associated with factor $\boldsymbol{F}_k$. The higher the value of β_k, the higher homogeneity in individuals' attitudes towards topic k. If $\beta_k = 1$, all individuals provide the same answer. Viceversa, if $\beta_k = 0$, there is maximum distribution heterogeneity, i. e. the individuals' answers are equally distributed across the J Likert scores. This means that no attitude prevails in

society.[9] The weight β_k associated with $\mathcal{F}_k$ is proportional to the strength of agreement among individuals about topic k.

The parameter θ_k specifies the direction of the intensity of $\mathcal{F}_k$, which is defined in absolute value. Looking at Eq. (5) and recalling the definition of $\mathcal{F}_k$, $\theta_k = +1$ if the sum of $F_k(i)$ over the n individuals is non negative; $\theta_k = -1$ otherwise.

The index $\log(T)$ reaches its minimum when all individuals reply to survey questions assigning the minimum score to all the K tolerance dimensions. In such a case, $\mathcal{F}_k = \left|\sum_{i=1}^{n} j\right| = \frac{J-1}{2}n$, $\beta_k = 1$ and $\theta_k = -1$, $\forall k$. The index formula reduces to:

$$\begin{aligned}\min(\log(T)) &= \underbrace{(-1)1\log\left(\frac{J-1}{2}n+1\right) + \ldots + (-1)1\log\left(\frac{J-1}{2}n+1\right)}_{\text{K times}} \\ &= -K\log\left(\frac{J-1}{2}n+1\right)\end{aligned} \tag{7}$$

The index $\log(T)$ reaches its maximum when all individuals assign the maximum score to all the considered dimensions. In such a case, $\mathcal{F}_k = \left|\sum_{i=1}^{n} j\right| = \frac{J-1}{2}n$, $\beta_k = 1$ and $\theta_k = +1$, $\forall k$. So, the index formula is simplified as follows:

$$\begin{aligned}\max(\log(T)) &= \underbrace{(+1)1\log\left(\frac{J-1}{2}n+1\right) + \ldots + (+1)1\log\left(\frac{J-1}{2}n+1\right)}_{\text{K times}} \\ &= K\log\left(\frac{J-1}{2}n+1\right)\end{aligned} \tag{8}$$

Notice that the T index is equal to zero in two different cases. The first case occurs when all individuals reply to all questions survey selecting the zero score in the rescaled Likert scale. This means that society is indifferent towards all tolerant dimensions, so the distribution of $\boldsymbol{F}_k$ is concentrated on the zero value of the normalized scale. If that happens for each $\boldsymbol{F}_k$ with $k = 1, ..K$, then $\log(T) = 0$.

The second case occurs when $\boldsymbol{F}_k$ has a uniform frequency distribution, i. e. individuals' responses are strongly heterogeneous. The value of β_k, which is a measure of homogeneity, is equal to zero, reflecting the fact that no attitude prevails on the others and this occurs for each dimension. Such responses do not contribute to determine the level of tolerance in the population. The index formula allows to identify which of the two cases occurred when we observe a value of the T index equal to zero.

9 These two cases are further discussed in the Appendix.

3.1 A Toy Example to Illustrate Numerical Calculations

In this section we present a simple example to illustrate numerical calculations in the steps involved by the index methodology.

Consider a population of 10 individuals to whom a questionnaire has been submitted to assess the level of tolerance in the population. Suppose the survey is composed of five items investigating two main dimensions of tolerance. Each item is measured by a 7-point Likert. Table 1 shows individuals' responses to the questionnaire items.

In this example, $\boldsymbol{X}$ is a 10×5 matrix, split in in two sub-matrices representing the two dimensions, as follows: $\boldsymbol{X} = [\boldsymbol{X}_{1(10\times3)}, \boldsymbol{X}_{2(10\times2)}]$, where matrix $\boldsymbol{X}_1$ collects data from the firsts three items (it_1, it_2, it_3); $\boldsymbol{X}_2$ summarizes data from the other two items (it_4, it_5).

We first rescale all the scores in order to shift the scale between -3 and $+3$, then we calculate the Cronbach's alpha (α_C) in order to verify the internal consistency of the two sub-matrices. Cronbach's alpha, indeed, is widely believed to indirectly indicate the degree to which a set of items measures a single unidimensional latent construct (Cortina 1993; Cronbach 1951). In the present paper, it evaluates the extent to which a group of items represents a specific dimension of tolerance. The Cronbach's alpha associated with the two submatrices are both relatively high $(\alpha_C(\boldsymbol{X}_1) = 0.738\,;\ \alpha_C(\boldsymbol{X}_2) = 0.700)$ leading us to conclude that the set of items in each submatrix correctly represents a specific dimension of tolerance.

Table 1: The data of the toy example.

Id	it_1	it_2	it_3	it_4	it_5
1	1	2	1	1	2
2	1	2	2	1	2
3	2	2	3	2	2
4	2	2	3	2	2
5	3	2	3	3	2
6	1	1	2	1	1
7	3	3	3	3	3
8	2	3	3	2	2
9	2	3	2	2	2
10	2	3	2	2	3

For each row of $\boldsymbol{X}_1$ and $\boldsymbol{X}_2$ we determine the median value,[10] which enters as element in vector $\boldsymbol{F}_1$ and $\boldsymbol{F}_2$, respectively (see Table 2). Intuitively, the median value measures the individual's tolerant attitudes towards a specific dimension of tolerance.

The elements in $\boldsymbol{F}_1$ and $\boldsymbol{F}_2$, considered in absolute value, are summed up. We obtain two numerical values $\mathcal{F}_1$ and $\mathcal{F}_2$ shown in Table 3, column 4. Column two reports the weight associated with each dimension, calculated according to (3). Both dimensions tend to concentrate on the negative values of the Likert scale ($\theta_1 = -1$, $\theta_2 = -1$). Moreover, the two dimensions show a low degree of homogeneity in the responses ($\beta_1 = 0.10$, $\beta_2 = 0.10$).

The normalized value of the Tolerance index reveals a quite low level of intolerance. It is calulated as follows:

$$\log(T)_{norm} = \frac{\log(T)}{\max(\log(T))} = \frac{-0.599}{6.868} = -0.087 \tag{9}$$

It can be interesting to compare the assessment of tolerance obtained with our index with an alternative measure based on a linear aggregation method. In the linear case, the index is reformulated as follows:

$$t = \theta_1\beta_1\mathcal{F}_1 + \theta_2\beta_2\mathcal{F}_2 \tag{10}$$

The normalized value of the linear index is obtained dividing $t/\max(t)$.

Table 2: Synthesis of the normalized sub-matrices into correspondent column vectors.

Id		$\boldsymbol{X}_1$		$\boldsymbol{F}_1$		$\boldsymbol{X}_2$	$\boldsymbol{F}_2$
1	−3	−2	−3	−3	−3	−2	−2
2	−3	−2	−2	−2	−3	−2	−3
3	−2	−2	−1	−2	−2	−2	−2
4	−2	−2	−1	−2	−2	−2	−2
5	−1	−2	−1	−1	−1	−2	−1
6	−3	−3	−2	−3	−3	−3	−3
7	−1	−1	−1	−1	−1	−1	−1
8	−2	−1	−1	−1	−2	−2	−2
9	−2	−1	−2	−2	−2	−2	−2
10	−2	−1	−2	−2	−2	−1	−1

10 Since $\boldsymbol{X}_2$ is composed of an even number of column vectors, we have two central values. The median is either the left middle number or the right middle number. As specificed in Section 3, the choice is made randomly.

Table 3: Parameter values of the Tolerance index.

Tolerance dimensions	β_k	θ_k	F_k
I	0.10	−1	19
II	0.10	−1	19

$$t_{norm} = \frac{t}{\max(t)} = \frac{-3.798}{60} = -0.063 \tag{11}$$

In order to explain the difference in the assessment due to the aggregation method, notice that the two tolerant dimensions, represented by $\boldsymbol{F}_1$ and $\boldsymbol{F}_2$, show a significant degree of correlation, measured by the Spearman's rank-order correlation coefficient: $corr(\boldsymbol{F}_1, \boldsymbol{F}_2) = 0.596$ (p value = 0.068). The linear index ignores such a relationship between dimensions.

4 Case Study

In this section, we employ the *T*-index to assess tolerance for a sample of 3,386 university students at the University of Milan-Bicocca located in the city of Milan. The data have been collected by means of a self-reported questionnaire. The list of items or questions is shown in Table 4.

Statements are phrased in agreement/disagreement form, and respondents were asked to indicate a score between 1 (strongly disagreed) and 7 (strongly agreed). We normalized the values in order to shift the scale between –3 and +3 and grouped items into five groups representing tolerance dimensions as follows : the firsts three items are supposed to investigate the Interreligious dialog; the fourth to sixth items are about Women/religion relationship; the seventh to eighth items are about Death/religion relationship; the 9th to 11th items investigate Multicultural society; the 12th to 13th items are on Homosexuality (Table 5).

We calculated Cronbach's alphas to check the internal consistency of item categories (Table 5). The results in Table 5 show a high degree of internal consistency for dimensions II, IV and V. The alpha values of Interreligious dialog (I) and Death/religion relationship (III) can be still considered acceptable.

Looking at the distributions of the median scores by category, $\boldsymbol{F}_k$ (Figure 2), it turns out that students have a propensity to be tolerant especially as regards to dimensions II, III, IV, and V. Indeed, the responses tend to be concentrated at the positive side of the normalized Likert scale.

Table 6 shows the values of the parameter β_k by dimension, which is the weight associated with each dimension in Eq. (6). As we explained in Section 3, higher the strenght of agreement about tolerance dimension k, i. e. higher the

Table 4: Items of the survey.

Item	Description	Likert scale						
		Strongly disagree						Strongly agree
		1	2	3	4	5	6	7
it_1	In your view, interreligious dialog may help to mitigate conflicts and misunderstandings in Italian society?	1	2	3	4	5	6	7
it_2	Is there the same freedom of religious practice for all religions in Italy?	1	2	3	4	5	6	7
it_3	Is there the same freedom of religious practice for all religions in your city?	1	2	3	4	5	6	7
it_4	The Catholic Church should accept the ordination of women to ministerial or priestly office?	1	2	3	4	5	6	7
it_5	The Muslim women should not pray in separate areas from men in the mosque?	1	2	3	4	5	6	7
it_6	The Jewish women should become rabbis?	1	2	3	4	5	6	7
it_7	Voluntary interruption of pregnancy is socially acceptable within the fifth month after conception?	1	2	3	4	5	6	7
it_8	Eutanasia is socially acceptable in presence of a living will?	1	2	3	4	5	6	7
it_9	The marriage between people of different religions is socially acceptable?	1	2	3	4	5	6	7
it_{10}	The marriage between people of different ethnic communities is socially acceptable?	1	2	3	4	5	6	7
it_{11}	Italian society may be enriched by the presence of foreign people of different religions?	1	2	3	4	5	6	7
it_{12}	All States should legally recognize same-sex marriage	1	2	3	4	5	6	7
it_{13}	All States should legally recognize the child adoption by same-sex couples.	1	2	3	4	5	6	7

homogeneity in median scores, higher the value of β_k. Dimension IV (Multicultural society) enters the formula with the highest weight, while dimension I (Interreligious dialog), which shows the most heterogeneous distribution, has the lowest value. For this dimension, intolerant attitudes of some individuals are partially compensated by tolerant attitudes of other individuals.

Table 5: Tolerance dimensions.

Tolerance dimensions	Description	Cronbach's alpha
I	Interreligious dialog $(it_1 - it_3)$	0.5222
II	Women/religion relationship $(it_4 - it_6)$	0.7935
III	Death/religion relationship $(it_7 - it_8)$	0.5753
IV	Multicultural society $(it_9 - it_{11})$	0.7334
V	Homosexuality $(it_{12} - it_{13})$	0.7390

Table 3 also shows the intensity of attitudes towards tolerance dimensions $(\mathcal{F}_k)$ and the direction of such intensity (θ_k). As for the latter, tolerant attitudes prevail for each dimension since $\theta_k = 1$, for all $k = 1, \ldots 5$. This result allows to establish that, even in the case of more heterogeneous distributions, tolerant attitudes more than offset intolerant attitudes. The intensity of tolerance is higher for the forth dimension (Multicultural society), followed by the second (Women/religion relationship), fifth (Homosexuality), and third (Death/religion relationship) dimensions.

Finally, $\log(T) = 16.5157$ and its range is $(-46.131\,;+46.131)$. The normalized version of the Tolerance index $\log(T)_{norm}$ is $\log(T)_{norm} = 0.3580$.

Table 7 shows the results by gender. We can see that all the dimensions contribute to a positive value of the tolerance index, as $\theta_k = 1$, for $k = 1, \ldots, 5$. Looking at Dimensions II, IV and V (Women/religion relationship, Multicultural society, and Homosexuality, respectively), the values of $\mathcal{F}_k$ are higher for women than for men indicating that the former tend to be more tolerant than the latter with respect these three dimensions. On the other hand, β_3 is much lower for women than for men (0.0970 vs. 0.3754). This indicates that the level of heterogeneity is high and no attitude towards the dimension on Death/religion relationship prevails among women. The most divisive topic within this dimension is about the voluntary interruption of pregnancy within the fifth month after conception. As a result, the dimension on Death/religion relationship weighs less in determining the overall degree of tolerance. Overall, the tolerance index for women is slightly higher and equal to 0.3487, while it is equal to 0.3149 for men.

To sum up, students show a propensity to be tolerant, women more than men. The index allows to establish by how much each dimension contributes to determine the degree of the overall tolerance. Most students are in favor of a multicultural society and agree about women's emancipation in the domain of religious authorities. They are open to homosexuality and respect the individual autonomy in the matters of life and death. The most controversial topic is about the interreligious dialog. The index allows to establish that tolerant attitudes in this respect more than compensate for intolerant attitudes.

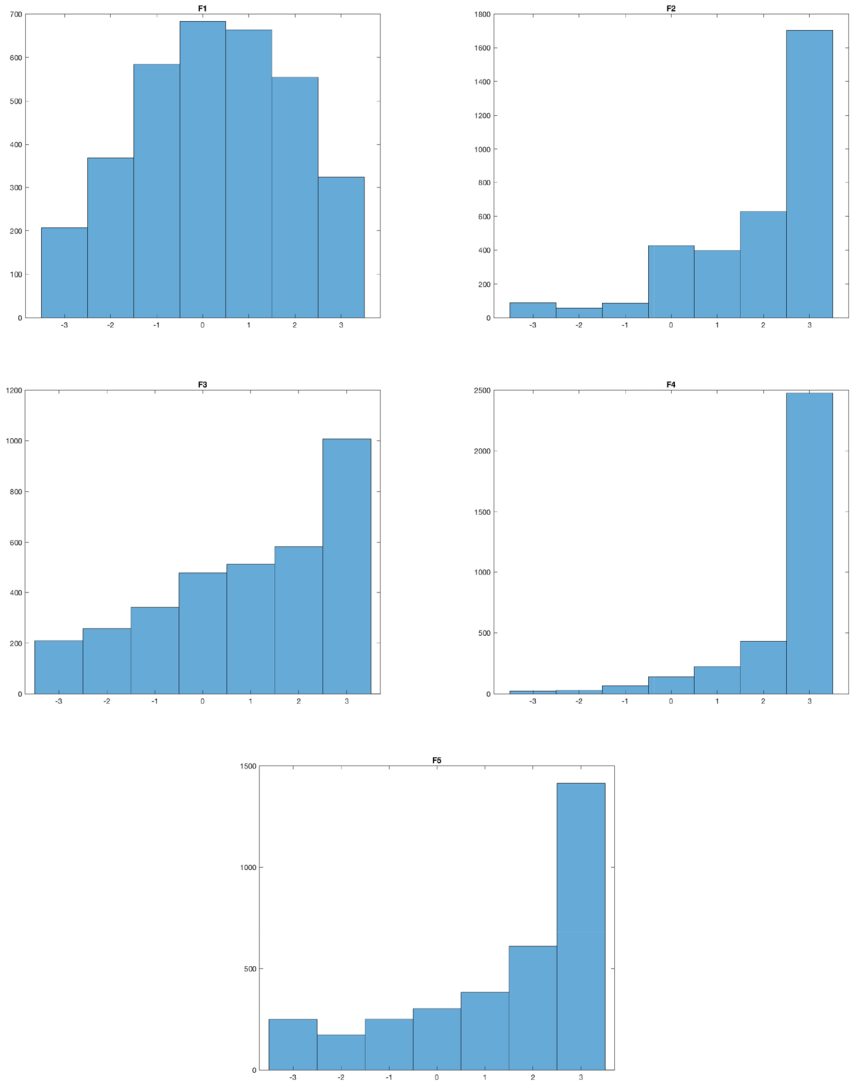

Figure 2: Graphical distribution of Tolerance dimensions F_k.

5 Conclusive Remarks

In this paper, we have addressed the issue of measuring tolerance viewed as a multifaceted concept encompassing a variety of social domains. To this aim, we have developed an index that aggregates all the tolerance indicators into a single

Table 6: Parameter values of T-index.

Tolerance dimensions	β_k	θ_k	F_k
I	0.0754	+1	805
II	0.4709	+1	6291
III	0.2554	+1	3633
IV	0.7350	+1	8328
V	0.3793	+1	4808

Table 7: Parameter values of T-index by gender.

Tolerance dimensions	α_k	β_k	θ_k	F_k
Men				
I	0.563	0.084	+1	325
II	0.826	0.376	+1	1,338
III	0.541	0.375	+1	1,189
IV	0.707	0.721	+1	2,049
V	0.773	0.153	+1	706
Women				
I	0.512	0.077	+1	478
II	0.770	0.508	+1	4,873
III	0.590	0.097	+1	1,992
IV	0.738	0.746	+1	6,173
V	0.713	0.426	+1	3,765

value. Such a measure of tolerance has the advantage of allowing easy comparisons between units of analysis, i. e. groups of students in our case or, more generally, countries, regions or cities. The index allows to determine the position of each unit in the ranking and the distance between them.

Notice that our tolerance index can be adapted to alternative definitions of tolerance, provided that information about the selected social domains is available and data are of Likert-scale type. For example, we could rely on the Qian (2013) definition that separates the concept of tolerance from diversity. In the case of our case study, we should neglect the dimension about multicultural society. Our analysis lead us to policy considerations. First, the government should promote socio-economic policies able to favors greater tolerance that, in turn, produces a number of positive socio-economic effects discussed in Section 2. Second, the

empirical results allow to modulate some important aspects from the policy makers point of view, such as the relative importance of different dimensions of tolerance. This type of information is particularly relevant to inform the debate on gaps in tolerance in different areas (city, region, country) or for specific groups of society.

Third, the empirical analysis highlights the importance for policy makers to establish information systems for monitoring attitudes towards the different dimensions of tolerance. This would significantly improve government's ability to detect disparities in tolerance dimensions and identify appropriate policy actions.

Finally, the tolerance index could be generalized for non Likert-scale type data.

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Appendix

The T index in the case of *J* even

In Section 4, we have considered a Likert scale with an odd number of response categories J in order to perfectly balance the scale points indicating positive and negative attitudes towards tolerance. Here we discuss the main implications for the Tolerance index when the Likert scale has an even number of categories. We will see that the T index is not substantially modified.

The first consequence of J even is that the scale does not have the middle or 'neutral' position, then the categories are no more equidistant as in the case of an odd number of scale points. The score chosen by the repondents could misrepresent their actual attitudes (Guy and Norvell 1977; Ryan 1980). The choice of adopting an even-numbered Likert-type scale could be made to press respondents to choose a sharp alternative instead of allowing refuge in a middle position (Lalla et al. 2004). Previous studies show that the percentage for the middle position in odd Likert scale decreases when the number of alternatives increases (Matell and Jacoby 1971). However, it is not straightforward to generalize this result since respondents are also sensible the nature of questions.

The second implication is that the normalized response vector of individual i is as follows(see Brown 1988):

$$it_m(i) = \left[-\frac{J}{2}, -\frac{(J-1)}{2}, \ldots -1, \ +1, .. + \frac{(J-1)}{2}, \ + \frac{J}{2}\right] \tag{12}$$

The single values of $F_k(i)$, defined as row median of each vector $X_k(i)$, are obtained just applying the definition of median recalled in Section 4.

Supplementary material on the computation of the T index.

As already shown in Section 4, the Tolerance index T (Eq. (6)) is obtained by computing the values $\mathcal{F}_k$ that measure the intensity of the assessment of respondents towards a certain topic. The parameter θ_k entering the formula identifies the direction of individuals' attitudes towards a topic. The parameter β_k measures the degree of homogeneity in responses about a topic.

Consider the case of respondents who select all the same scale point, and this occurs for each topic k. The degree of homogeneity is maximum and it is associated with many possible data configurations. In the following, we discuss only one of these possible configurations since the other can be treated in the same way. In the second part of this Section, we will discuss a case of maximum heterogeneity.

In Figure A is depicted an example of maximum agreement among individuals in rating each Tolerance dimension F_k.

The absolute frequency is maximum at the selected point and this occurs for each tolerance dimension. The relative frequency distributions of the Likert-scale points chosen by the respondents can be reduced to a single value for each $\boldsymbol{F}_k$. This value is obtained summing up all the sample assessments (Table A).

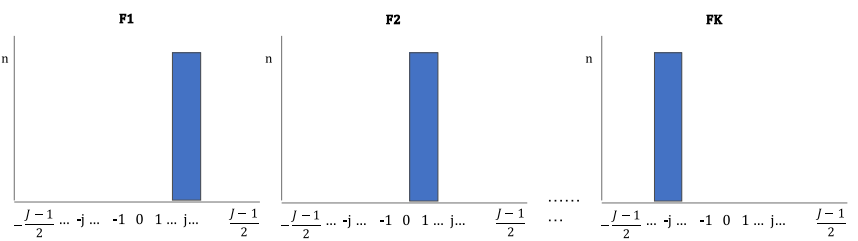

Figure A: Distribution of tolerance dimensions $\boldsymbol{F}_k$ in case of maximum homogeneity.

Table A: Frequency distributions per dimensions: maximum homogeneity of assessments.

F_1			F_2				F_K		
Values	**Count**	**Relative Frequency**	**Values**	**Count**	**Relative Frequency**	....	**Values**	**Count**	**Relative Frequency**
J	n	1	1	n	1	....	$-j$	n	1

The Leti's heterogeneity index is $L_k = 1$, $\forall k$. The parameter $\beta_k = 1 - \frac{1-1}{J-1} = 1\ \forall k$, while the value of parameter θ_k is obtained according to the positive/negative sum of respondents' scores.

The Tolerance index log(T) is as follows:

$$\begin{aligned}\log(T) &= (\theta_1)\beta_1 \log(F_1 + 1) + (\theta_2)\beta_2 \log(F_2 + 1) + \ldots + (\theta_K)\beta_K \log(F_K + 1) \\ &= (+1)1 \log(j \cdot n + 1) + (+1)1 \log(1 \cdot n + 1) + \ldots + (-1)1 \log(-j \cdot n + 1)\end{aligned}$$

Consider now the case of individuals who assign a different score such that each tolerance dimension has the same absolute frequency n/J.[11] This a case of maximum heterogeneity of individual attitudes (see Figure B).

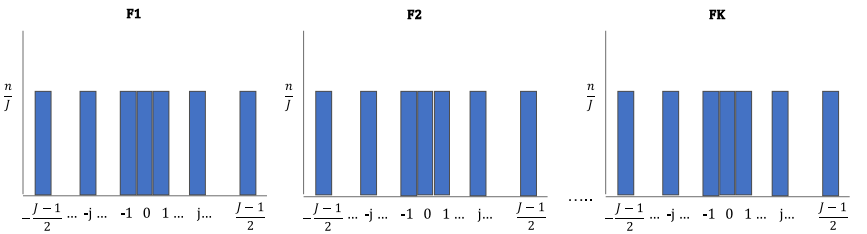

Figure B: Distribution of Tolerance dimensions $\boldsymbol{F}_k$ in case of maximum heterogeneity.

Accordingly, Likert-scale scores have the same relative frequencies across different dimensions $\boldsymbol{F}_k$ (Table B). This implies that $f_{\left(-\frac{J-1}{2}\right)} = .. = f_{(-j)} = \ldots = f_{(-1)} = f_{(0)} = f_{(1)} = .. = f_{(j)} = \ldots = f_{\left(\frac{J-1}{2}\right)}$.

11 Without lost of generality we can consider the value n/J as integer.

Table B: Frequency distributions per dimensions: maximum heterogeneity of assessments.

F_1			F_2			....	F_K		
Values	**Count**	**Relative Frequency**	**Values**	**Count**	**Relative Frequency**		**Values**	**Count**	**Relative Frequency**
$\frac{-J-1}{2}$	$\frac{n}{J}$	$f_{\left(\frac{-J-1}{2}\right)}$	$\frac{-J-1}{2}$	$\frac{n}{J}$	$f_{\left(\frac{-J-1}{2}\right)}$	....	$\frac{-J-1}{2}$	$\frac{n}{J}$	$f_{\left(\frac{-J-1}{2}\right)}$
$-j$	$\frac{n}{J}$	$f_{(-j)}$	$-j$	$\frac{n}{J}$	$f_{(-j)}$	....	$-j$	$\frac{n}{J}$	$f_{(-j)}$
-1	$\frac{n}{J}$	$f_{(-1)}$	-1	$\frac{n}{J}$	$f_{(-1)}$	....	-1	$\frac{n}{J}$	$f_{(-1)}$
0	$\frac{n}{J}$	$f_{(0)}$	0	$\frac{n}{J}$	$f_{(0)}$	....	0	$\frac{n}{J}$	$f_{(0)}$
1	$\frac{n}{J}$	$f_{(1)}$	1	$\frac{n}{J}$	$f_{(1)}$	....	1	$\frac{n}{J}$	$f_{(1)}$
j	$\frac{n}{J}$	$f_{(j)}$	j	$\frac{n}{J}$	$f_{(j)}$	....	j	$\frac{n}{J}$	$f_{(j)}$
$\frac{J-1}{2}$	$\frac{n}{J}$	$f_{\left(\frac{J-1}{2}\right)}$	$\frac{J-1}{2}$	$\frac{n}{J}$	$f_{\left(\frac{J-1}{2}\right)}$	....	$\frac{J-1}{2}$	$\frac{n}{J}$	$f_{\left(\frac{J-1}{2}\right)}$
Total	n	1	*Total*	n	1	....	*Total*	n	1

The Leti's heterogeneity index $L_k = J$, $\forall k$; the parameter $\beta_k = 1 - \frac{J-1}{J-1} = 0$; $\theta_k = +1$, $\forall k$. Tolerance index log(T) in this case is obtained by computing:

$$\begin{aligned}\log(T) &= (\theta_1)\beta_1 \log(F_1 + 1) + (\theta_2)\beta_2 \log(F_2 + 1) + \ldots + (\theta_K)\beta_K \log(F_K + 1)\\ &= (+1)0 \log\left(\frac{n}{J}\left(-\frac{J-1}{2} + \ldots. + \frac{J-1}{2}\right) + 1\right) + \ldots\\ &\ldots + (+1)0 \log\left(\frac{n}{J}\left(-\frac{J-1}{2} + \ldots + \frac{J-1}{2}\right) + 1\right) = 0\end{aligned}$$

Table C: Empirical papers on tolerance.

Author(s)	**Measurement of tolerance**
Florida (2002, 2003)	– Gay Index: share of the gay and lesbian population. – Bohemian Index: share of the artistic population. – Melting Pot Index: the share of the immigrant population.
Noland (2005)	– The share of population in favor of protecting culture from foreign influence. – The share of population according to which homosexuality should be tolerated.

Table C: (continued)

Author(s)	Measurement of tolerance
Florida et al. (2008), Quian (2013)	– Average of the Gay Index and the Bohemian Index.
Boschma et al. (2009)	– Share of regional population in bohemian occupations. – Share of foreign-born people.
Berggren and Elinder (2012)	– Share of population that does not dislike to have people of a different race as neighbors. – Share of population that does not dislike to have homosexuals as neighbors.
Gani (2015)	– Social measures of tolerance: the stock of migrants. – Women's participation in government. – Institutional and political measures of tolerance: political and civil rights. – The rule of law; voice and accountability.
Schmutzler and Lorenz (2017)	– Index given by the first component of a principal component analysis based on World Value Survey questions about people of a different race of a different religion immigrants or foreigners.
Audretsch (2018)	– SPARTACUS International Gay Travel Index (Source: Spartacus World Guide: https://www.spartacusworld.com/gaytravelindex.pdf. – For China: Number of active users on Blued, the most popular gay dating app in China.

References

Adriani, F., Matheson, J.A., and Sonderegger, S. (2018). Teaching by example and induced beliefs in a model of cultural transmission. Int. J. Econ. Behav. Organ. 145: 511–529.

Adriani, F. and Sonderegger, S. (2009) Why do parents socialize their children to behave pro-socially? An information-based theory. J. Publ. Econ. 93: 1119–1124.

Audretsch, D., Seitz, N., and Rouch, K. (2018). Tolerance and innovation: the role of institutional and social trust. Eurasian Bus. Rev. 8: 71–92.

Berggren, N. and Elinder, M. (2012). Is tolerance good or bad for growth? Public Choice 150: 283–308.

Bisin, A. and Verdier, T. (2001). The economics of cultural transmission and the dynamics of preferences. J. Econ. Theor. 97: 298–319.

Boschma, R.A. and Fritsch, M. (2009). Creative class and regional growth: empirical evidence from seven european countries. Econ. Geogr. 85: 391–423.

Brown, J.D. (1988). *Understanding research in second language learning: a teacher's guide to statistics and research design*. London: Cambridge University Press.

Cerqueti, R., Correani, L., and Garofalo, G. (2013). Economic interactions and social tolerance: a dynamic perspective. Econ. Lett. 120: 458–463.

Corneo, G. and Jeanne, O. (2009). A theory of tolerance. J. Publ. Econ. 93: 691–702.

Cortina, J. (1993). What is coefficient alpha? an examination of theory and applications. J. Appl. Psychol. 78: 98–104.
Cronbach, L.J. (1951). Coefficient alpha and the internal structure of tests. Psychometrika 16: 297–334.
Decancq, K. and Lugo, M. (2013). Weights in multidimensional indices of wellbeing: an overview. Econom. Rev. 32: 7–34.
Decataldo, A., Liberati, C., Michelangeli, A., and Tognetti, M. (2019). Millenials and religion: divergence or continuity compared to the generation of their parents? Relig. Soc. 1: 2–19.
Florida, R. (2002). *The rise of the creative class*. New York: Basic Books.
Florida, R. (2003). Cities and the creative class. City Community 2: 3–19.
Florida, R. and Gates, G. (2003). Technology and tolerance: the importance of diversity to high-tech growth. Res. Urban Pol. 9: 199–219.
Florida, R., Mellander, C., and Stolarick, K. (2008). Inside the black box of regional development: human capital, the creative class and tolerance. J. Econ. Geogr. 8: 615–649.
Fusco, E. (2015). Enhancing non-compensatory composite indicators: a directional proposal. Eur. J. Oper. Res. 242: 620–630.
Gani, A. (2015). Measures of tolerance and economic prosperity. Int. J. Soc. Econ. 43: 71–85.
Greco, S., Ishizaka, A., Tasiou, M., and Torrisi, G. (2018). On the methodological framework of composite indices: a review of the issues of weighting, aggregation, and robustness. Soc. Indic. Res. 141: 61–94.
Guy, R.F. and Norvell, M. (1977). The neutral point on a likert scale. J. Soc. Psychol. 95: 199–204.
Lalla, M., Facchinetti, G., and Mastroleo, G. (2004). Ordinal scales and fuzzy set systems to measure agreement: an application to the evaluation of teaching activity. Qual. Quant. 38: 577–601.
Leti, G. (1965). Sull'entropia, su un indice del gini e su altre misure dell' eterogeneità di un collettivo. Metron. 24: 332–371.
Matell, M.S. and Jacoby, J. (1971). Is there an optimal number of alternatives for likert scale items? study 1: reliability and validity. Educ. Psychol. Meas. 31: 657–674.
Munda, G. and Nardo, M. (2009). Noncompensatory/nonlinear composite indicators for ranking countries: a defensible setting. Appl. Econ. 41: 1513–1523.
Noland, M. (2005). Religion and economic performance. World Dev. 33: 1215–1232.
OECD (2008). Handbook on Constructing Composite Indicators: methodology and user guide. Paris: OECD Publishing.
Osgood, C.E. (1964). Semantic differential technique in the comparative study of cultures. Am. Anthropol. 66: 171–200.
Ottaviano, G.I. and Peri, G. (2006). The economic value of cultural diversity: evidence from us cities. J. Econ. Geogr. 6: 9–44.
Piccolo, D. (1998). *Statistica*. IL Mulino.
Qian, H. (2013). Diversity versus tolerance: the social drivers of innovation and entrepreneurship in us cities. Urban. Stud. 50: 2718–2735.
Reese, L.A. and Sands, G. (2008). Creative class and economic prosperity: old nostrums, better packaging? Econ. Dev. Q. 22: 3–7.
Ryan, M. (1980). The likert scale's midpoint in communications research. Journal. Q. 57: 305–313.
Schmutzler, J. and Lorenz, E. (2017). Tolerance, agglomeration, and enterprise innovation performance: a multilevel analysis of latin american regions. Ind. Corp. Change 27: 243–268.
Shi, Y. and Pan, M. (2017). Evolutionary dynamics of social tolerance in the economic interaction model with local social cost functions. Appl. Econ. Lett. 24: 75–79.

Shi, Y. and Peng, D. (2014). Dynamics of social tolerance in the economic interaction model with three groups. Appl. Econ. Lett. 21: 665–670.

van Praag, B.M.S., Frijters, P., and Ferrer-i Carbonell, A. (2003). The anatomy of subjective well-being. J. Econ. Behav. Organ. 51: 29–49.

World-Values-Survey-Association (2015). *World value survey 1981–2015 official aggregate v.20150418*. URL www.worldvaluessurvey.org.