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Fuzzy Sets and Systems ●●● (●●●●) ●●●—●●●

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sets and systemswww.elsevier.com/locate/fss

Modeling uncertainty in monetary poverty: A possibility-based approach

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Received 4 August 2014; received in revised form 9 November 2015; accepted 12 November 2015

Abstract

Fuzzy sets theory has successfully accommodated the lack of clear-cut boundaries of poverty and its gradual nature. On the other hand, uncertainties related to lack of knowledge and imprecision in poverty data need also to be accounted for. The accuracy of poverty analysis is highly subject to how well these features are adequately addressed. We argue that possibility theory is an appropriate framework to deal with incomplete knowledge in poverty. Indeed, considering “the possibility of poverty” instead of the “probability of poverty” allows us to achieve a more realistic handling of this phenomenon. Empirical possibility distributions of monetary poverty states are derived based on our previous works and alpha-cut analysis is used to explore their features. Also, collective possibilistic poverty measures for each state are computed along with an aggregate possibilistic poverty ratio. This possibilistic modeling is applied to the analysis of poverty in Tunisia in 2005 and 2010.

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Keywords: Possibility theory; Fuzzy sets theory; Uncertainty modeling; Unidimensional poverty analysis; Alpha-cut analysis

1. Introduction

A new stream of research on poverty has questioned the rigid and ad hoc division of population into poor and non-poor. This has also pointed out the difficulty to draw a clear cut-off point between poverty state and its opposite, especially that a person who earns one cent above a poverty line Z is considered as not poor and that a person who earns one cent less than a poverty line Z is classified as poor. Accordingly, poverty is no longer viewed as an attribute characterizing an individual in terms of its presence or absence but instead as a matter of degree. Fuzzy sets theory [31] has allowed to move away from the poor/non-poor dichotomy and to consider instead the state of poverty or well-being of a person as a matter of degree. Indeed, application of fuzzy techniques to unidimensional and multidimensional poverty analysis has flourished in recent years. We can cite for instance among others the works of Cerioli and Zani [5], Cheli and Lemmi [6], Lemmi and Betti [23], and Betti et al. [3] as the major contributions to this field. So, fuzzy sets

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<http://dx.doi.org/10.1016/j.fss.2015.11.009>

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theory has well accommodated the idea of gradualness in belonging to the fuzzy poverty set. However, we need also to tackle another issue related to incomplete knowledge and imprecise data (usually households tend to downsize or inflate declared revenues or expenditures in surveys) on poverty predicates.

In the framework of fuzzy sets theory, we define the degree to which an element belongs to the fuzzy poverty set (the fuzzy set of poor households or individuals) given a known value of a poverty predicate (proxy) variable X . Possibility theory allows us instead to evaluate the more or less plausible values of an uncertain poverty predicate variable X given the information we have on the belonging of this element to the fuzzy poverty set. Possibility theory has been introduced by Zadeh in 1978 [33] as an extension of the theory of fuzzy sets. Substantial contributions to this theory have been made by Dubois and Prade (see for instance Dubois and Prade [14–17], and Dubois et al. [13]). Possibility theory has been successfully used to tackle incomplete and uncertain knowledge in a wide range of scientific fields including artificial intelligence [2], epidemiology [4], radiology [9], finance [25] and transportation [22], among others. We refer the reader to the work of Alola et al. [1] for a review of literature on various applications of possibility theory.

Possibility theory has not been yet applied to research in poverty measurement and modeling. However, uncertainties intrinsic to poverty phenomenon are related to imprecision as well as to lack of information and incomplete descriptions about it. Also, the measurement of poverty based on a poverty line Z has mainly relied on expert judgments (see for example among others Ravallion and Bidani [28] and Greer and Thorbecke [19,20]). Raufaste et al. [27] argue that human judgments of uncertainty conform better to possibility theory and that uncertainty in human affairs often requires ordinal handling. Linguistic uncertainty may be related also to poverty concept, considered as a linguistic variable. For example, when we are told the sole information that “household 1 is poor”, we are not able to give a precise estimation of his annual per capita income (annual per capita expenditures).

Let’s consider the following statement: “The annual income of a poor household 1 is below Z ”. The threshold Z is represented by the classical poverty line. According to this classical framework, lack of information in monetary poverty predicates (the annual income or per capita expenditures of a poor household) is not accounted for. The mechanism governing poverty is treated as aleatory. Hence, the truthfulness degree of this proposition (which is 0 or 1) is usually treated by means of logit models, where the probability of poverty equals the probability that the annual income of a poor household is below Z . On the contrary, fuzzy sets theory advocates the idea of gradualness (truthfulness degree of the proposition between $[0, 1]$) instead of Booleanity (truthfulness degree is 0 or 1).

Monetary poverty data (income or expenditures) are crucial for devising poverty measures and designing adequate policies to fight this phenomenon. It is then highly recommended to account for imprecision in poverty predicates (income or expenditures) and possibility theory is well suited for modeling this type of uncertainty [33]. So, according to this theory, the mechanism governing poverty is no longer treated as aleatory and “possibility of poverty” is conceptualized instead of “probability of poverty”. Indeed, setting poverty modeling within a possibilistic framework seems imperative for theoreticians to fairly specify what we know and what we do not know as regards poverty. It is also crucial for practitioners and policy makers to understand the scope and the limit of academic research in the field. Furthermore, this bestows analysis with more scientific credibility and allows to gain better accuracy for the sake of more effective poverty monitoring policies.

The purpose of this paper is then to explore the application of possibility theory to unidimensional poverty analysis and to find out all what this may bring to poverty measurement and modeling in terms of interpretation, accuracy and more realistic conceptualization of this phenomenon.

The article is organized as follows. In the next section, we review possibility theory. In Section 3, we explain the methodology we suggest for a possibilistic modeling of monetary poverty analysis. We conduct in Section 4 a real data application to the Tunisian case in 2005 and 2010 and we discuss and compare results. Section 5 concludes the study.

2. Review of possibility theory

The concept of a possibility distribution is defined as a fuzzy restriction on the values that may be assigned to a variable. Let X be a variable, taking its set of values in the range Ω .

$$X = x,$$

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