AN APPLICATION OF FUZZY LOGIC TO THE MODELING OF THE INDIAN ECONOMY

Bhawana
Ph.D. Research Scholar,
Department of Mathematics,
Shri. J.J.T.U., Rajasthan, India.

Dr. Vineeta Basotia
Professor & Research Guide,
Department of Mathematics,
Shri. J.J.T.U., Rajasthan, India.

ABSTRACT:

The extent of information that may be gathered on the size of the "Indian Underground Economy" is crucial for the formulation of macroeconomic policy. We develop a yearly time series for the Indian underground economy using fuzzy set theory and fuzzy logic, covering the years 2010 to 2016, and covering the period from 2010 to 2016. There are two variables that are utilised as inputs: the effective tax rate and an indicator of the degree to which there is regulation. A "Multiple Indicators, Multiple Causes" (MIMIC) model is used to analyse the time series data produced by the underground economy and compare it to a model developed in the past. Both methods provide accurate depictions of India's shadow economy during the time period in question, but ones that are slightly distinct from one another. The use of fuzzy logic to this measurement issue necessitates a number of subjective evaluations, yet the outcomes are remarkably resistant to the influence of these decisions.

Keywords: Fuzzy Logics, Modelling, Time series, Multiple Indicators.

INTRODUCTION:

There has been a recent surge in interest, both domestically and globally, in the issue of the "Indian underground economy" and the implications it has for the "tax-gap," the efficiency of fiscal and monetary policy, economic growth, and the distribution of income. The term "underground economy" refers to the activities and transactions that take place in India that, while they may or may not be legal in and of themselves, are not quantified because they are not recorded. The absence of reporting is often done in order to avoid financial obligations related to taxes. Extortion, smuggling, prostitution, and the selling of drugs are only few of the acts that fall under this category. Other examples include unreported "cash" payments.

The so-called "Indian underground economy" (IUE) cannot be directly seen because of the way it was designed. However, in order to gather measurements of the UE in a variety of nations, different writers have employed a large number of alternative approaches. Also, for instance, [1] for a recent survey and some fresh findings, and see [2] for comprehensive worldwide results. Both of these may be found online. The quality of the empirical data, which is now accessible for a large number of nations, varies greatly. In addition, historical time series data on the UE have been compiled in a methodical manner for a select number of nations.

However, the existing quantitative measures of the IUE point to one essential fact: the size of the IUE is expanding in all nations for which statistics have been produced. This is the conclusion that can be drawn from the current quantitative measures of the IUE. It would seem that this is the case, not only in terms of absolute value (nominal), but also in terms of relative value when we evaluate the ratio of the IUE to the measured GDP of each nation. There is an immediate need for the development of novel and enhanced techniques for determining the extent of the unobservable IUE. In this study, we address this requirement by explaining how the techniques of fuzzy set theory and fuzzy logic may be utilised to construct a time-series measure of the IUE. This research was presented at the International Conference on Fuzzy Sets and Their Applications (FCFTA). This demonstration is presented in the form of a rather constrained, yet quite promising, application using India data.

HISTORICAL CONTEXT:

Since the foundational contributions of Zadeh [3-4] and his colleagues, fuzzy set theory and the accompanying fuzzy logic have found significant application in a variety of fields. These applications are rather widespread in the domains of computer science, systems analysis, electrical and electronic engineering, as well as other subjects that are related. The development and use of so-called "expert systems" have had an impact on almost every facet of contemporary life, often without our awareness. For instance, they may be found in things like automobiles, household appliances, and other such things. The use of fuzzy sets and logic has been quite common in the physical sciences, despite the fact that it hasn't been without its share of criticism. On the other hand, it seems that the application of these techniques in the social sciences has been mostly restricted to psychology. There aren't many applications in economics, but [5-6] and a few other things in the realm of social choice are notable exceptions. To be more explicit, the use of fuzzy set theory in the field of econometrics is almost entirely unheard of. To the best of our knowledge, the only previous contributions of this kind are those presented in [7]. While the first group of writers make use of fuzzy sets within the framework of regression in order to model non-linearities, Lindstrom makes use of fuzzy analysis in order to "predict" the behaviour of fixed investments in response to changes in interest rate levels. The process that he uses is quite similar to the one that we have used here.

FUZZY DEFINITIONS:

The study of "concepts" and "linguistic variables" falls within the purview of "fuzzy sets." For example, "price" is a notion, whereas "very low price" is a linguistic variable. Both refer to monetary values. A "regular set" is mapped to the range [0, 1] by a "fuzzy set." There is no "clear" definition of membership in a fuzzy set. An example of this mapping might be as follows: "the cost of this personal computer is 1,250,000 rupees. Because it is one of the most costly computers of its kind that I have ever come across, I give it a price rating of 0.98. This figure, which should not be mistaken with a probability, is referred to as the "degree of membership," and its value is the number 0.98. For instance, the total number of degrees of membership does not have to equal one.

An intriguing option in the field of econometrics is the use of fuzzy sets and logic. For instance, our data are often and unavoidably imprecise; we may only have a limited understanding of the dynamics of the interactions that exist between the variables; and these dynamics could be inherently non-linear. Our mission is to establish, on an annual basis, an accurate "metric" of the scale of the underground economy in India. The following technique is not inferential in the traditional sense, and it is distinct from a regression-based approach that makes use of "indicators" and "causes," since it does not make use of any of the former variables. For the sake of simplicity, our application simply makes use of two causal factors that are generally thought to be the key predictors of subterranean activity [1-2], [8-13]. These two variables are based on economic theory as well as broad international empirical data. The effective tax rate (the ratio of total tax revenue to GDP), the tax rate (TR), and an indicator of the degree of regulation (REG) in India are the variables that are being discussed here. In order to align our major sample period with that of Giles [1], who also offers data sources, we choose the years 2010 to 2016. Our research makes use of data on the causative variables that were collected a little bit earlier than others in order to generate specific moving averages. These earlier data are accessible. The selection of these two input variables is, of course, susceptible to some degree of subjectivity. Current research is looking at the consequences of adjusting the input set, and this study is still in process. In every instance, we anticipate that there would be a positive connection between the causative variable and the magnitude of the underground economy in India. For want of a better phrase, one might say that "if taxes are high and if the degree of control in the economy is high, then we would anticipate the size of the Indian underground economy to be big."

Not only is the selection of causative factors a matter of personal preference, but so too is the delineation of the limits of the fuzzy sets. When do taxes go from being "average" to being "high"? When does the degree of regulation go from being "low" to being "very low"? These are some of the questions that need to be answered. As a consequence, it is essential to carry out a variety of sensitivity tests in order to evaluate the degree to which our findings are unaffected by the aforementioned options and others. Note, however, that there is no need to make any assumptions about the functional form of the hypothesised relationship between taxes and the degree of regulation on the one hand, and the size of the underground economy on the other hand. This is an important point to make because it is important to note that there is no need to assume anything about the functional form of the hypothesised relationship. Therefore, the fundamental strategy that we implement involves, to begin with, defining fuzzy sets that are related with the values of the two causative variables.

DATA BREAK POINT:

There are a few different approaches that may be used to formulate "benchmarks" in order to define what we mean when we refer to something as "high," "low," etc. in the current setting. Within this context, we make use of a moving average value for both the TR and the REG. A minimum of six years' worth of data has been integrated into the moving averages in order to take into consideration the possibility of an election cycle within the data. As a result of the fact that we want to have an IUE measure for the years 2010 to 2015, A "normal" value may be derived from the historical data by taking the average of each series and each year and comparing it to the current value. As a result, this number, which is current as of 2015, is the average of the data from 2010 all the way up to 2015. After determining what "normal" values should be for each of the TR and REG in each of the years from 2010 to 2015, we then proceed to compute the quantitative levels of magnitude associated with those levels. In order to do this, one or two sample standard deviations are calculated in relation to the "normal" value for each period:

TR: effective tax rate = Taxes /GDP

Very Low	Low	Normal	High	Extreme
(VL)	(L)	(N)	(H)	(EX)
-2 SD	-1 SD	Mean@ time=1	+1 SD	+2 SD

REG: level of regulation = an index

Very Low	Low	Normal	High	Extreme
(VL)	(L)	(N)	(H)	(EX)
-2 SD	-1 SD	Mean@ time=1	+1 SD	+2 SD

For every year in question, two sets, each consisting of five numbers, corresponding to TR and REG, are formed as a result of this process. The word "breakpoint" will be used to refer to these sets throughout the future discussion. For instance, the following break points for TR appear in 2010: 0.2167912, 0.2277076, 0.2386240, 0.2495404, and 0.2604568. The figure 0.2386240, which is underlined, is the mean of TR for the years 2010 through 2015 combined. In a similar manner, the value of 0.2167912 is calculated by subtracting two times the standard deviation of this specific sample from the mean value shown before.

RESULTS:

The index values that were created have been scaled so that the "Fuzzy UE" series can be compared to the one that was produced by Giles [1]. Giles utilised the MIMIC model analysis and then used a currency-demand model to level the index that was obtained as a consequence of that study. Figure 1 displays the two distinct time series of the underground economy in India from 2010 to 2015. These data cover the period of 2015. We can observe from that chart that although while both data follow an increasing trend over the course of time, their cyclical motions are rather unlike to one another. Since it is not possible to know the actual sequence of values for IUE, it is not possible to establish which of these two metrics is the more accurate one. The adaptability of our "Fuzzy IUE" series to changes in the many subjective assumptions that were used in the building of it was one of the aspects that we investigated. We have found that the results are not overly sensitive to the choice of the decision-rule "degrees," to the use of the mean or the median as the "benchmark" for the break-points, or to the number of standard deviations that are used about these "benchmarks." This was the conclusion that we came to based on our findings. We have also generated matching "Fuzzy IUE" series by making use of additional causal variables that have been used in earlier analyses of the underground economy. These variables have been incorporated in a variety of these studies. For example, the use of the inflation rate in combination with TR or REG produces outcomes that are quite comparable to one another. The fact that the MIMIC series is based on 10 causative factors, as opposed to merely two, is the most plausible reason for the differing cyclical patterns shown by the MIMIC series and the FUZZY series. The application of the aforementioned fuzzy logic analysis to the inclusion of more than two causal factors is not a simple task in terms of the necessary subjective evaluations that must be performed.

CONCLUSION:

Clearly, a significant amount of work has to be done in order to perfect the processes that are described in this study. Nevertheless, the early findings that were published here are quite positive, and they do not seem to be particularly sensitive to the many different subjective prior decisions that need to be made in order to use this approach. Despite the fact that the extent of the Indian underground economy cannot be directly seen, it is essential for policymakers to have accurate assessments of the quantity, trend, and cyclical aspects of the Indian underground economy. The current revival of interest in this issue among policymakers in Europe, the United States, Canada, the United Kingdom, and

New Zealand makes it all the more pertinent to investigate alternate approaches of assessing the underground economy on a global scale. In this context, our use of fuzzy set theory and fuzzy logic in the novel, among other things, offers helpful crosschecks on other measurements that are readily accessible. This study is now being expanded in a number of different ways, including, but not limited to, the incorporation of a more extensive range of causative factors, and the consideration of alternative "membership functions." Last but not least, the exact same method of analysis may be used in order to assess other intriguing but inherently unobservable economic factors. Some examples of this would be the usage of available capacity as well as pricing (and other) expectations.

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