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A fuzzy logic approach to modelling the New Zealand underground economy

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Abstract

The availability of data for the size of the "underground economy" (UE) is important for macroeconomic policy. We use fuzzy set theory and fuzzy logic to construct an annual time-series for the (unobservable) New Zealand UE over the period 1968–1994. Two input variables are used—the effective tax rate and an index of the degree of regulation (REG). The resulting UE time-series is compared with one previously constructed by the second author using a structural "multiple indicators, multiple causes" (MIMIC) model. The two approaches each yield sensible, but somewhat different, pictures of the New Zealand UE over this period. The fuzzy logic approach to this measurement problem involves several subjective judgements, but our results are quite robust to these choices.

Keywords: Fuzzy logic; Fuzzy sets; Underground economy

1. Introduction

There is renewed interest internationally in the problem of measuring the size of the "underground economy" (UE), and determining its implications for the size of the "tax-gap", for the effectiveness of fiscal and monetary policy, for the rate of economic growth, and for income distribution. The UE involves activities and transactions which may themselves be legal or illegal, but which are not measured because they go unreported. The lack of reporting is generally to evade tax liabilities. Examples of these activities include unreported "cash" payments, manipulating cash register records, extortion, money laundering, smuggling, prostitution, narcotics sales, etc.

By its very nature, the UE is not directly observable. However, many different methods have been used, by various authors, to obtain measures of the UE in different countries. For example, see Giles [3] for a recent survey and some new results, and Schneider and Enste [9] for extensive and comparative international results. The empirical evidence, now available for many countries, is of widely varying quality. In addition, there are few countries for which historical time-series data on the UE have been constructed on a consistent basis. For the most part, estimates have been made on a rather sporadic basis.

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However, the available quantitative measures of the UE point to one important fact—the size of the UE has been growing over the past two or three decades in all countries for which data have been constructed. This appears to be the case, not only in absolute (nominal) terms, but also in relative terms when we consider the ratio of the UE to the measured gross domestic product (GDP) of each country.

For example, Schneider and Enste [9] provide compelling international evidence to this effect, and detailed such results for New Zealand and for Canada are reported by Giles [3] and by Giles and Tedds [6], respectively. Accordingly, there is an urgent need for new and improved methods for measuring the size of the unobservable UE. In this paper, we address this need by illustrating how the tools of fuzzy set theory and fuzzy logic can be used to generate a time-series measure of the UE. This illustration takes the form of a rather limited, but very promising, application with New Zealand data.

Section 2 discusses some of the basic principles associated with fuzzy sets, and outlines our general methodology. The step-by-step details of this methodology are provided in Section 3; and the results based on the New Zealand data are described in Section 4. The Section 5 provides our conclusions, and discusses some of the prospects for further research on this topic.

2. Background principles

2.1. Historical context

Fuzzy set theory and the associated fuzzy logic have found widespread application in many disciplines since the seminal contributions of Zadeh [14,15] and his colleagues and followers. These applications are extensive in computer science, systems analysis, electrical and electronic engineering, and related fields. The construction and application of "expert systems" has touched most aspects of modern life, often without our knowledge. Examples include their use in domestic appliances, motor vehicles, and the like.

While the use of fuzzy sets and fuzzy logic has been widespread in the physical sciences (although not without some criticisms, historically), the application of these tools in the social sciences appears to have been limited mainly to psychology. Applications in economics are few, though some interesting exceptions are the studies of Dasgupta and Deb [2], Richardson [8], and Sengupta [10], and others in the field of social choice.

More specifically, the use of fuzzy set theory in econometrics is virtually unknown. To our knowledge the only other such contributions are those of Shepherd and Shi [12] and Lindström [7]. The former authors use fuzzy sets in a regression context to model non-linearities in a Philips curve model, while Lindström uses fuzzy analysis to "predict" fixed investment behaviour on the basis of interest rate levels and their changes. Because we are concerned with predicting, or estimating, the size of the unobservable UE, our own analysis here follows Lindström's methodology quite closely.

2.2. Some definitions

"Fuzzy sets" deal with "concepts" and "linguistic variables". For instance, "price" is a concept, and the notion, "rather low price" is a linguistic variable. A "fuzzy set" maps from a regular set to [0, 1]. Membership of a fuzzy set is not "crisp". An example of this mapping would be: "the price of this personal computer is US$ 10,000. This is one of the most expensive such computers I have ever seen, so I rate