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An illustration of variable precision rough sets model: an analysis of the findings of the UK Monopolies and Mergers Commission

Malcolm J. Beynon^{a,*}, Nigel Driffield^b

^a*Cardiff Business School, Cardiff University, Colum Drive, Cardiff, Wales CF103EU, UK*

^b*Business School, University of Birmingham, UK*

Abstract

This paper introduces a new technique in the investigation of limited-dependent variable models. This paper illustrates that variable precision rough set theory (VPRS), allied with the use of a modern method of classification, or discretisation of data, can out-perform the more standard approaches that are employed in economics, such as a probit model. These approaches and certain inductive decision tree methods are compared (through a Monte Carlo simulation approach) in the analysis of the decisions reached by the UK Monopolies and Mergers Committee. We show that, particularly in small samples, the VPRS model can improve on more traditional models, both in-sample, and particularly in out-of-sample prediction. A similar improvement in out-of-sample prediction over the decision tree methods is also shown.

Scope and purpose

The Monopolies and Mergers Commission (MMC) in the UK evaluates whether a given firm, or set of firms is behaving in a manner that is considered to be against the public interest, that is anti-competitive. The interpretation and prediction of the decisions made by the MMC is of importance to firm's possible future investment plans. Through the construction of decision rules using the variable precision rough sets (VPRS) model this interoperation and prediction is able to be undertaken. The importance of the concomitant variables in the decisions made is shown through a 'leave n out' Monte Carlo simulation approach. At the technical level this study illustrates one of the first applications of VPRS in an economic environment.

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* Corresponding author. Tel.: +44-29-2087-5747; fax: +44-29-2087-4419.

E-mail address: beynonmj@cardiff.ac.uk (M.J. Beynon).

1. Introduction

This paper elucidates an alternative approach to the analysis of limited-dependent variables in an economic application and may be considered to be particularly useful where one is seeking to explain observed behaviour. The example that is employed here concerns the decisions reached by a regulatory body, the Monopolies and Mergers Commission (MMC) in the UK. The methodology that is primarily investigated here is a variable precision rough sets model (VPRS) which is a development on the original rough set theory (RST). The reason that such an approach can be considered applicable here, is that it effectively derives a set of *decision rules* based on observed behaviour.

The essential aim concerns the extent to which it is possible to predict, in terms of the likely determinants whether an industry is found to be acting against the public interest, and therefore whether a remedy to this situation is suggested. Traditional statistical methods allow for some understanding of the data, but these methods often include a priori assumptions on the data, e.g. discriminant analysis with assumptions on its within group variances [1]. An advantage over the more traditional approaches is that this it is not beset by the small sample problems of regression models. This is appropriate here due to the small inherent population in the example considered.

RST was initially developed by Pawlak [2,3], its philosophy is founded on the assumption that with every object of the universe of discourse there is some associated information, data or knowledge [4]. Comparisons have been made to other methods such as discriminant analysis [1,4–6], logistic analysis [6] and neural networks [7,8]. Indeed, the utilisation of RST with the more traditional neural networks is an example of its own development [9]. With increased computing power, commercial applications based on RST were and are continually developed (e.g., RoughDAS and RoughClass [10], RSES [11]). Papers relating to business and economics studies that have used RST include [6,12], who investigated the use of RST within bankruptcy risk, and [13], who looked at the prediction of company acquisition. Their findings both showed the benefits of RST in identifying rules based on financial variables to aid the classification of a companies bankruptcy and company acquisition potential respectively.

Ziarko [14,15] constructed VPRS, which includes a probabilistic generalisation on RST. An et al. [16] applied VPRS (they called it *enhanced RST*) to discovering rules in water demand. Further applications utilising VPRS include the investigation of education spending across US state [17] and corporate failure prediction [18]. To strengthen the need for VPRS over RST, when discussing computer-based decision techniques in a corporate failure setting, [19, p. 468] stated:

‘In real world decision making, the patterns of classes often overlap, suggesting that predictor information may be incomplete... . This lack of information results in probabilistic decision making, where perfect prediction accuracy is not expected.’

The purpose of this paper therefore is to extend the use of VPRS in an explicit manner, to determine the appropriate set of decision rules within a transparent methodology. This will evaluate the decisions taken by the UK MMC when evaluating whether a given firm, or set of firms is behaving in a manner that is considered to be *against the public interest*, that is *anti-competitive* [20]. Here we contrast the use of VPRS, with that of the more traditional (at least in economics) approaches to explaining

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